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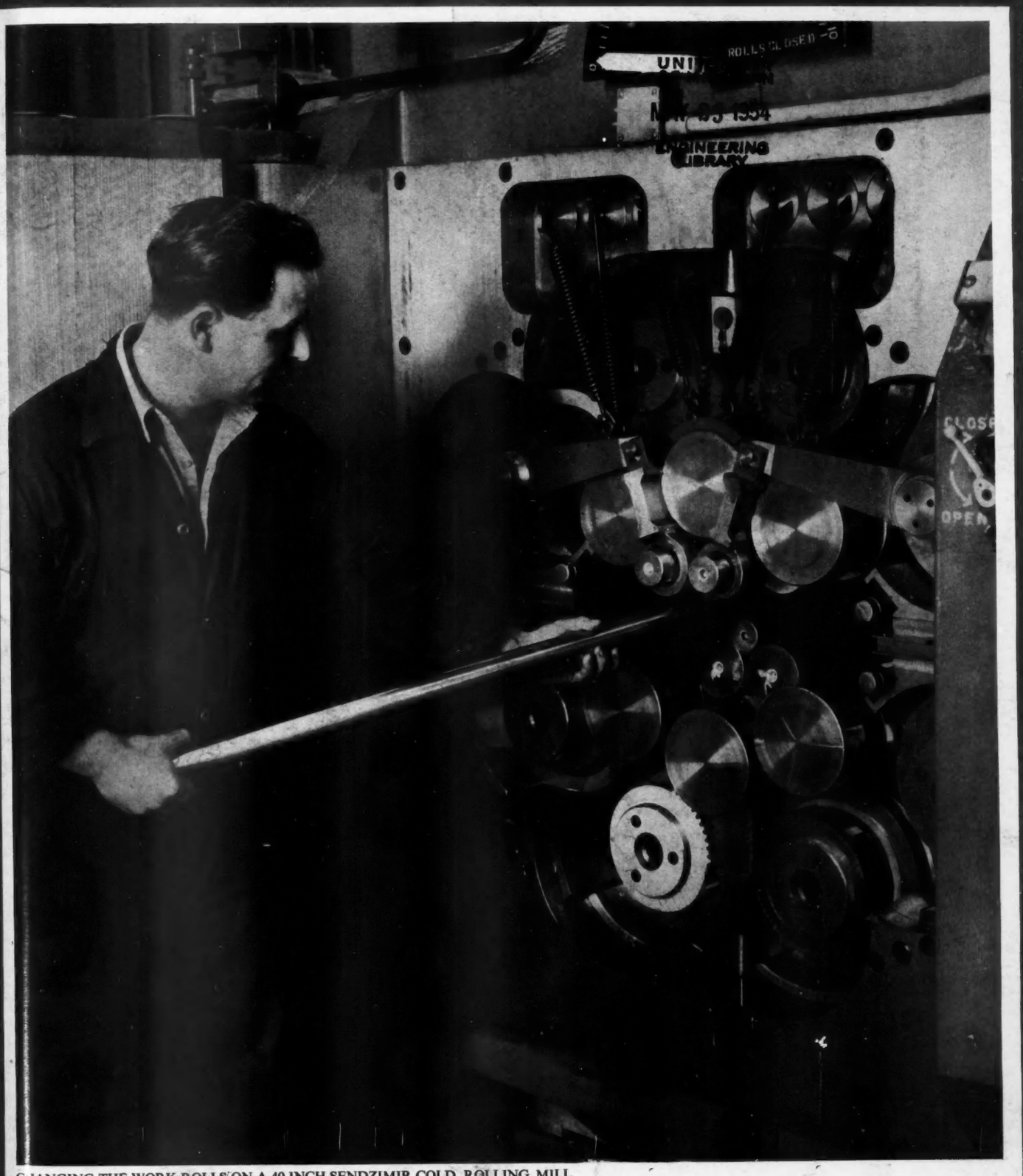

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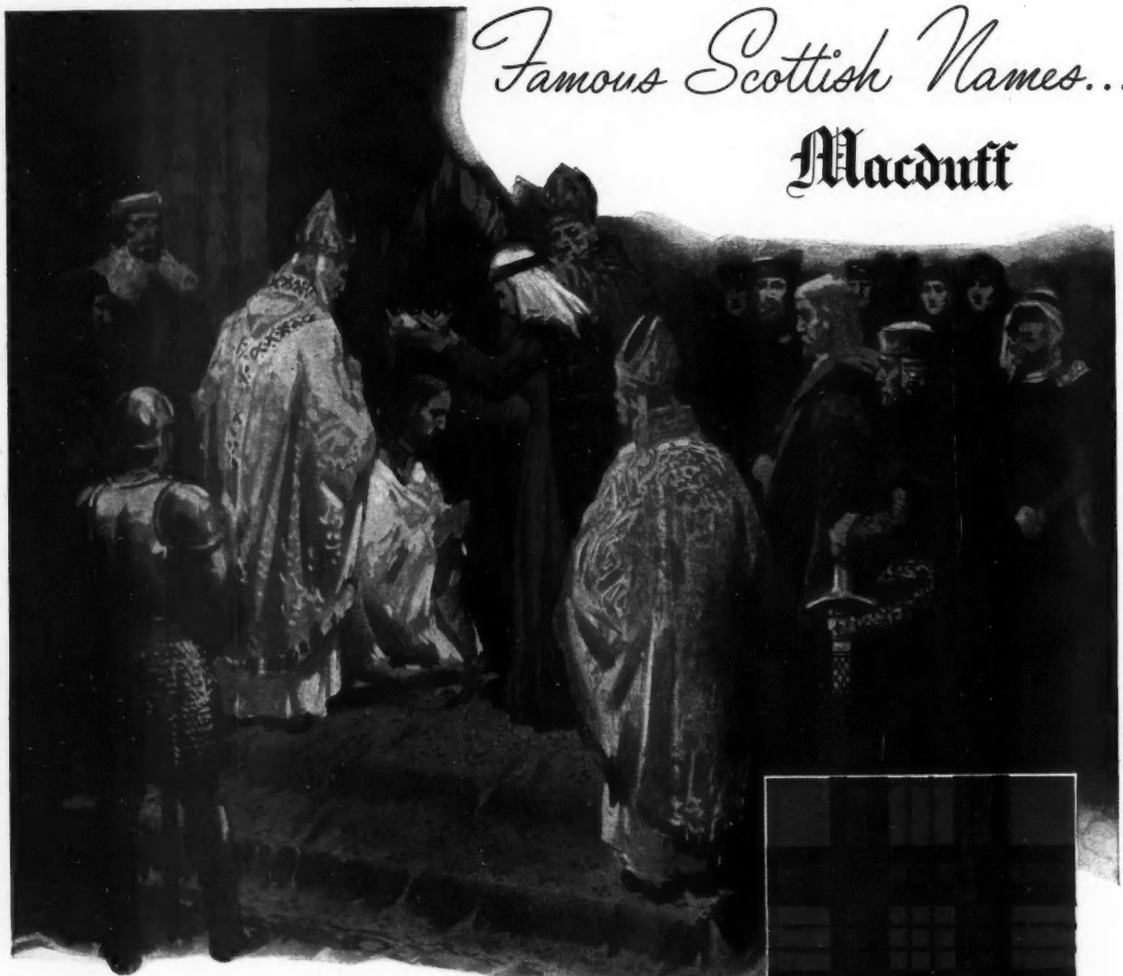
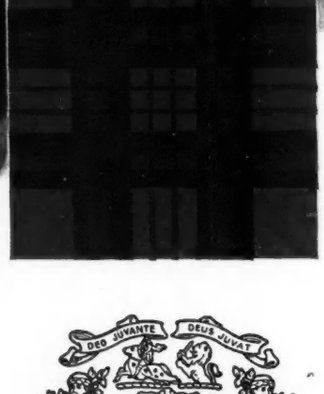
Famous Scottish Names...

Macduff



The family name of the first or Celtic Earls of Fife was Macduff. For services rendered to Malcolm Canmore they obtained privileges known as the "Law Clan Macduff" which included the right to seat the King in the Royal chair on his Coronation day. The most famous occasion on which this privilege was exercised was when Isabella, Countess of Buchan, a Macduff, led Robert the Bruce to the place of Coronation at Scone in 1306. For this daring and highly courageous act, this lady, an ardent patriot, was imprisoned later by Edward I in a cage on the walls of Berwick. Her brother, Duncan, Earl of Fife, was on the opposing side and captured by Bruce and imprisoned in Kildrummie Castle, Aberdeenshire. This ancient earldom became extinct in 1425. The climax in the fortunes of the modern line was reached when an Earl of Fife married, in 1885, the eldest daughter of Edward VII (then Prince of Wales). The marriage of their daughter to H.R.H. Prince Arthur of Connaught in 1913 merged this ancient line of the Duffs into a branch of our reigning house.



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THE NEW UNIVERSITY

THE lot of the present-day engineering student is, like that of the operatic policeman, "not a happy one"; and there is evidence to show that, as time goes on, it may become progressively more difficult. This is, of course, partly due to the increases in technical knowledge which have recently taken place and have led to syllabus congestion; and partly to the theory that an intensive training in technology alone is unlikely to turn out men who are sensitive, mature, integrated and socially responsible. The conflict between these opposing factors was the theme of a lecture by Professor Arnold Tustin at the Massachusetts Institute of Technology a few months ago, the occasion being the commemoration of the establishment at that Institute of the Edwin Sibley Webster professorship in electrical engineering. Webster, it may be recalled, was a pioneer in fostering technical education, and endowed the chair which Professor Tustin is occupying for a year as visiting professor. Professor Tustin's permanent position is head of the Department of Electrical Engineering in the University of Birmingham.

"To provide education that is adequate for social needs, both in respect of the high technical level of training and in respect of breadth of knowledge and interests and personal and emotional development is," said Professor Tustin, "a very onerous specification"; and there will be few who will disagree. In fact, in trying to meet it the possibility that there may be no solution, without at least radical changes or compromises, must not be overlooked. To relieve the situation, however, he suggests, firstly, that technical training should be spread over much more of man's life than his years at the university, by providing improved means of continued education in all its forms. Secondly, where the calibre of the student will not allow more, only a narrow pinnacle of specialisation should be built on a broad base of general scientific training. Thirdly, more attention should be given to the proper classification of entrants, both in relation to ability and to the general type of work for which they are being trained, it being difficult, if not impossible, to devise curricula which are equally suitable for the engineer-manager and the "back-room" analyst.

It may be admitted that these requirements are sound, if arguable. Professor Tustin, however, goes a good deal further. He demands from the student not only technical knowledge but a mastery of at least his own language. He also demands an acquaintance with the main lines of human history, with the status and limitations of current beliefs about man's place in the universe and his evolutionary origins; and some knowledge of the working of economic systems and of their relationship to recent economic history and current controversy. Before we have recovered our breath from reading this catalogue of requirements, he adds, "I do not see that there is much else that is obligatory. To ensure basic common factual knowledge of this sort is not difficult." But it would require the student "to scorn delights and live laborious days."

He is equally provocative in asserting that all our knowledge should be applied to improving the lot of humanity and that the best brains, instead of drifting into an elaboration of mechanisms, should be diverted to fundamental research in the social, economic and psychological sciences. We should become increasingly concerned with human psychology, a branch of science which will be as indispensable in studying the world as quantum mechanics is in understanding semiconductors. What matters most, in fact, are motives and purposes; and it is our business to understand and master them. The new university should therefore give human development priority over technology with the object of discovering how science may more completely serve the true well-being of man.

Professor Tustin illustrated this revolutionary thesis by indicating the part that electrical engineering could play in this development. It could eliminate those areas of the world where poverty and ignorance are still rampant, by increasing agricultural, mining and other productivities. The manufacture of nitrogenous fertilisers and the smelting of metals, as well as the economic development of water power and the design of more efficient equipment, are other fields of activity. The problem of converting chemical energy directly into electrical energy should also be tackled, so as to circumvent the second law of thermodynamics. Electrical engineering was, in fact, a basic need for development no less than was the application of engineering methods of analysis, which were already the working tools of the neurologist and biologist, to the study of recession and boom in the economic system.

These views must not lightly be dismissed as idealistic. They are worthy of study and constructive criticism. Nevertheless, to implement them will be difficult. It will demand of the universities an ability to resist pressure from industry and to turn to the fundamentals with which they have always been concerned.

Weekly Survey

THE B.I.F.

The British Industries Fair opened on Monday this week. At Castle Bromwich, Birmingham, the main sections are devoted to engineering, electrical and electronic equipment, building and heating, hardware, and heavy plant in the outdoor section. At Olympia, London, the exhibits are mostly consumer goods, though there are scientific and optical instruments, office appliances, and packing and printing machinery, Prefabricated buildings, as well as foodstuffs, textiles and suction cleaners are shown at Earls Court. Last week it was announced that a new organisation, British Industries Fair, Limited, had been set up to take over the organisation and management of the 1955 and subsequent Fairs. Sir Arthur J. G. Smout, J.P., has been appointed chairman.

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PISTON-ENGINE DEVELOPMENT

Present-day trends in power units for passenger-service vehicles are continued with the introduction, by the Rootes group of companies, of a new Diesel-type engine which is described in detail elsewhere in this issue. The engine operates on a two-stroke cycle, has opposed pistons, and the porting arrangements are based on the Kadency principle. Most internal-combustion engines for commercial vehicles, and for road vehicles generally, are of the " in-line " type, though some V-types are to be found, particularly in America, where the " V-8 " is being produced on an increasing scale. The main feature of this type of engine is its short rigid structure, the layout permitting a well-balanced and evenly-stressed cylinder block to be designed; recent models have employed shorter working strokes than formerly, so giving crankshafts of greater rigidity with larger journal overlaps.

The new engine has been in the process of development for three or four years, and, with its horizontal arrangement, appears to have the advantages of a V-type engine – a compact cylinder block and rigid crankshaft; it is, however, more simple, for it has six opposed pistons requiring only three cylinders between them. This has also meant that only one fuel injector is required for each pair of pistons, thus making for simplicity, and, no doubt, some saving in cost. The two-stroke cycle and the porting adopted have also allowed the number of moving parts to be reduced. It is claimed that knock has been eliminated and combustion efficiency improved, which should help in the present campaign against the noise and smell of Diesel-driven road vehicles.

Recent months have seen other new piston engines making their appearance in this country, and it is to be expected that others will follow in spite of claims that the gas-turbine would soon become predominant in all fields. Last week we described the " Nomad " engine, a two-stroke, horizontally-opposed turbo-Diesel aero-engine and, in our issue of May 1, 1953, there was a description of the " Deltic," an opposed-piston type of engine with the cylinder arranged in the form of an equilateral triangle. These engines, together with that just introduced, are important stages in the continued development of the high-speed internal-combustion engine.

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RESEARCH IN INDUSTRY

The theme of the two principal speeches at the annual luncheon of the British Electrical and Allied Industries Association, which was held at the Connaught Rooms, London, on Friday, April 30, was the paramount necessity of applying the results of scientific research to industry.

In proposing the toast of " E.R.A." Viscount Waverley said that the first World War had shown how backward we were in making this application. The result had been the establishment of the Department of Scientific and Industrial Research, industrial research assocations, university grants and assistance to individuals in various forms. All these efforts had led to an impressive expansion. The time had now come, however, to take stock and to ask whether a change of emphasis was not necessary. Was there, he inquired, a proper balance between fundamental and industrial research; or was the former being carried beyond the boundaries of useful application? Such application depended less on money than on the availability of men and materials; the question was whether we had enough technologists to match the scientists. He was struck with the smallness of the contributions some large firms (not in the electrical industry) made to their Research Associations, compared with what they spent on their own work. This was a shortsighted policy which did not contribute to the prestige of industry.

In reply, the President of the Association (Sir Lawrence Bragg) said that they had been promised a capital grant of £100,000 provided they secured £200,000 from industry. Some £195,000 had already been subscribed. He would like to think that his election as president was due to his connection with the Royal Institution. For were it not for the work of Faraday in the cellars of the Albemarle-street building, electrical engineers would not exist. This work was a reminder of the importance of pure research even when the ultimate applications might be obscure.

This was an important time in the history of the Association as the new laboratories at Leatherhead would soon be opened. The difficulties of applying the results of research to industry (to which Lord Waverley had referred) must not be minimised. It must be remembered that there were two extreme types of man between which there was a psychological gap that it was hard to bridge. The scientist could make 100 failures and be justified in one success. He must not make up his mind until he had amassed all the evidence. He must try to separate one problem from all the others and study it in isolation. There could not be a greater contrast with the man of affairs, who had to take every factor into consideration, to make rapid and prior decisions on insufficient evidence and who could not isolate phenomena and study them in the simplest form. To bridge this gap was the main function of such bodies as the Electrical Research Association.

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DEARER COKE

The increase in the average basic prices of coal, announced by the National Coal Board on April 14, came into effect on Monday, May 3. In an official statement, the Joint Iron Council, 14, Pall Mall, London, S.W.1, representing the producers of foundry pig-iron and the iron-founding industry, point out that the latter industry will be heavily hit by the rise in the price of coking coal. The industry will suffer both through its use of pig-iron, embodying higher charges for blast-furnace coke, and its consumption of coke for its own melting purposes. The Council feel that serious effects will be inevitable as a result of the sharp upward movement of coke prices ; they put the increase at an average of about 5*s.* 8*d.* per ton of coke produced. It is considered that these effects will make themselves felt almost immediately in many industries. The Joint Iron Council do not believe that the price increases are justified, either as regards coal in general or coking coal in particular. They add that they feel strongly that the whole question of the National Coal Board's policy in further increasing the price of coal, with dangerous consequences to industry and perhaps to employment, should be thoroughly and critically examined on the floor of the House of Commons.

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TRADE WITH THE U.S.S.R.

Improvements during recent months in British trade with the Soviet Union were referred to by Sir Greville S. Maginness, K.B.E., in his presidential address at the annual general meeting of the Russo-British Chamber of Commerce in London on April 29.

Sir Greville began by reminding members that trade between the two countries was, in the main, complementary and not competitive. He stated that, since the beginning of this year, firm orders had been placed with this country by Soviet importing organisations for goods to the value of between £30 million and £40 million. These had included substantial orders for trawlers, textile machinery, rolling-mill plant, milk-bottling machinery, machine tools, woodworking machinery, Diesel-generating sets, power cables, switchgear, and many other types of electrical and industrial equipment.

It would be seen that, so far, orders had largely followed the traditional pattern of trade between the two countries, but there were some grounds for anticipating that subsequent orders might be extended to certain types of manufactured consumer goods. The existing need for increasing exports from Great Britain to meet the cost of the country's imports, and to maintain the standard of living of its inhabitants, was such that no opportunity should be lost of expanding its business overseas. It seemed vital, therefore, that the improved prospects of trade between Britain and the Soviet should be fully explored.

Now that responsibility for the purchase of timber, grain and canned goods had been returned from Government control to private enterprise, British importers would have an important role to play in implementing the desired expansion of trade between the countries.

During a recent British trade visit to Moscow, a statement was issued by the Soviet Minister for Foreign Trade showing that, given the appropriate conditions for bringing about normal trading relations, Russian organisations might place orders in this country to the value of 4,500 million roubles (about £400 million) during the three years 1955 to 1957. Commodities expected to be ordered would include such items as ships, power equipment, forging and pressing equipment, machine tools, textile and food-manufacturing machinery, as well as some types of raw materials, food and manufactured consumer goods.

In this connection, Sir Greville stressed the importance of direct personal contacts between buyers and sellers as the only satisfactory way of concluding trade negotiations. Russian business men were competent and well qualified, technically and commercially.

The chamber is a joint Anglo-Soviet organisation which has for its object the promotion of commerce between the British Commonwealth and the U.S.S.R. It was incorporated in Britain in 1916, under the auspices of the Association of British Chambers of Commerce, and is affiliated to that body.

This aerial view of the Owen Falls Dam was taken from a B.O.A.C. aircraft on the day the scheme was inaugurated by Her Majesty the Queen. Lake Victoria, the source of the Nile, is just out of view on the right of the picture. An existing road and rail bridge is shown on the right. When the time comes to allow the water above the dam to rise to the designed height, the road part of the bridge will be submerged and traffic will use the road over the dam.

INDUSTRIAL DEVELOPMENT IN UGANDA

ELECTRICITY FROM THE OWEN FALLS DAM

A visitor to Uganda cannot fail to be impressed by the immense potentiality for industrial development of the Protectorate – industrial development in which engineering must inevitably play a large part. The Owen Falls hydro-electric scheme which the Queen inaugurated last week has been commissioned only just in time to meet the rapidly growing demand for electricity. The two turbines now in use each provide 15 MW, but the turbine room has been designed for a total of ten such sets.

The Nile, from its source in Lake Victoria to Lake Albert, about 250 miles downstream, drops 1,700 ft. The total potential hydro-electric capacity of the river between these lakes is 2,000 MW, sufficient to have met the entire electricity requirements of Britain before the second World War. To harness this power, additional hydro-electric plants can be built at several places in the future. The flow of the river cannot be fully regulated for the generation of electricity, since the water is used for the irrigation of Egypt and the Sudan. If it could, a continuous output of 102 MW would be practicable at Owen Falls. After discussions with the Egyptian Government, therefore, the design was prepared on the basis of a minimum flow corresponding to a continuous output of 81·5 MW. Transport limitations restricted the size of the individual turbo-generator sets to 15 MW, and the station has been designed for ten sets giving a firm generating capacity at peak load of 135 MW with one set in reserve. This will enable the agreed minimum flow of the river to be fully utilised with an overall load factor of 60 per cent.

The growth of industry since the war, and of its basic power – electricity – is apparent. In 1948, the revenue of the Uganda Electricity Board was £70,000; this year it is expected to be £700,000. The number of units generated in 1953 was 50 per cent. more than in 1952, and the number of street lights installed rose by 58 per cent. The various loads estimated by the Board for 1959, the year in which revenue is expected to be sufficient to meet all costs, are: general demand (domestic and small power users), 25,000 kW; the new textile factory, 9,000 kW; bulk supply to Kenya, 35,000 kW; and copper smelting, 6,000 kW, giving a total of 75,000 kW.

Uganda's prosperity is shown, also, by the increase in imports: for every 100 motor-cars imported in 1950 there were 246 in 1952. Imports of motor cycles rose from 45,000 in 1950 to 107,000 in 1952. When the copper mine at Kilembe in the west of Uganda is completed, and treatment and smelting plants have been installed there and at Jinja (close to Owen Falls), the output will be about 18 million lb. of copper and 900,000 lb. of cobalt a year. Drilling at Sukulu last year has revealed the possibility of recovering 100,000 tons of apatite and a million lb. of pyrochlore annually. At Jinja it is expected that the new textile mill will be started by the end of 1955, thus rendering the Protectorate less dependent on Japan for the processing of cotton, the chief product of this predominantly agricultural community. The Kilembe mine will be served by the railway, which is now being extended from Kampala. The line will eventually reach to Kasese, 205 miles from Kampala, and will open up wide stretches of undeveloped country for the benefit of the African people.

A sidelight is thrown on industrial development by a paragraph in the Protectorate's annual report for 1953 – a most illuminating publication which gives a general picture of the country and provides a bibliography for anyone interested in the possibility of trade or individual enterprise in Uganda.* "A new Factories Ordinance dealing with safety, health and welfare in factories, based on the United Kingdom Factories Act of 1937, was brought into operation (in 1953). Unfortunately, the difficulty in recruiting suitable Factory Inspectors prevented general progress in this field. A start was made, however, on the examination of steam boilers, and many deficiencies were brought to light." There are more than five million Africans in Uganda, but only a very small number are employed, if, for census purposes, only employers of five or more are included. The majority of the Africans live off the land.

The country is, however, rapidly becoming conscious of the significance of electricity in relation to its prosperity. Considerable efforts have been made in this direction, and in the larger towns the African can see the results for himself. In Kampala, for instance, during the week of the Queen's visit to Uganda many

* *Colonial Reports; Uganda* 1953. H.M. Stationery Office.

The partly built power station is visible in this aerial view, which was also taken on the day of the Queen's visit.

buildings were floodlit. The churches and mosques, some of them built on the hills which encircle the town, were picked out by colour floodlighting, and below them, in the town, the white facing of the new telephone exchange stood out.

Educated Africans in Uganda are undoubtedly aware of the immense scope in their country for industrial development. Some, at least, are also conscious of the importance of maintaining friendly relations with British contractors and consulting engineers, whatever the future may hold politically. Engineering education in the Protectorate has a long way to go before there can be an adequate number of native professional engineers, but meanwhile British firms will find plenty of opportunities in Uganda.

The Owen Falls Scheme is thus the symbol and the result of the country's intention to broaden and extend the base of its economy. The design and construction have already been described in ENGINEERING (page 496, April 16, and page 528, April 23, 1954), but the two photographs reproduced in this article show a feature which could not be shown before – namely, the road over the dam – since the main concrete road units were only completed shortly before the Queen's visit. For about 20 minutes before Her Majesty formally inaugurated the Scheme the sluice gates were closed: the flow of the Nile along its first two miles – the distance from Lake Victoria to the dam – was stopped, and the pool below the sluice gates rapidly emptied.

The Owen Falls Construction Company was founded after the war, under a different name, to rebuild the port of Rotterdam. When that work was finished they took over the Owen Falls scheme, where they have employed (in order of numbers) African, Indian, British, Italian, Dutch, Danish and Austrian workers. The Governor of Uganda, Sir Andrew Cohen, paid a tribute to everyone who has taken part in the work, and especially to his predecessor, Sir John Hall, who pressed forward with the scheme at a time when there was considerable inertia to be overcome. At Government House on the day prior to the opening, Her Majesty invested Mr. C. R. Westlake, chairman of the Uganda Electricity Board, as a Knight Bachelor; Dr. H. Olivier, principal in Uganda of Sir Alexander Gibb and Partners, as a Companion of the Order of St. Michael and St. George; and Mr. J. M. Stock, chief electrical engineer of the Board, as an Officer of the Order of the British Empire.

PERSONAL

SIR ANDREW MACHARG has expressed a wish to retire from the board of the North British Locomotive Co., Ltd., and the directors recommend that his place be taken by MR. HUGH COWAN-DOUGLAS. They also propose that MR. H. A. SIEPMANN be elected to the board.

COLONEL S. J. M. AULD, O.B.E., M.C., D.Sc., has been elected President of the Institute of Petroleum, 26 Portland-place, London, W.1, for the year 1954-55. He served as President of the Institute in 1937-38.

MR. P. L. JONES, director of Swan, Hunter, and Wigham Richardson Ltd. and of the Wallsend Slipway and Engineering Co. Ltd., has been elected President of the North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne, 1, for 1954-55.

MR. J. P. FORD, managing director of Associated British Oil Engines (Export) Ltd., and other companies has been elected chairman of Council of the Institute of Export.

MR. K. B. ROSS, O.B.E., M.A., B.Sc., until 1951 general refineries manager, Anglo-Iranian Oil Co., Abadan, and who has since been on the board of Costain-John Brown, Ltd., has been appointed director of production of the Industrial Group of the Department of Atomic Energy at Risley. MR. P. T. FLETCHER, B.Sc. (Eng.), chief engineer, Ministry of Works, has been appointed deputy director (engineering services) in the Industrial Group. Both appointments take effect as from June 1.

COLONEL B. H. LEESON, T.D., C.B.E., M.I.E.E., has been re-elected chairman of the Association of Short-Circuit Testing Authorities.

MR. H. S. WINGATE, vice-president and a director has been elected President of the International Nickel Co. of Canada, Ltd., in succession to DR. P. D. MERICA. MR. F. M. A. NOBLET, assistant treasurer, has been elected treasurer in place of MR. W. J. HUTCHINSON. Dr. Merica and Mr. Hutchinson have both attained the retirement age, but will continue to serve as directors and members of the executive committee.

MR. E. A. MOORE, head of the industrial pyrometry and power-plant sales department of the Cambridge Instrument Co., Ltd., has retired after 51 years of service with the company.

Following the resignation of MR. A. G. PEACOCK, B.Sc., A.R.I.C., A.Inst.P., as secretary of the Scientific Instrument Manufacturers Association of Great Britain, 20 Queen Anne-street, London, W.1, announced on page 389, *ante*, MR. E. D. HART, M.A., A.Inst.P., A.M.I.E.E., has been appointed deputy director and MISS G. E. MOSS, B.A., formerly clerk to the Council, has now taken up the position of secretary. Mr. Hart takes up his post on June 1.

MR. RALPH LYSELL, the Swedish designer has joined the industrial design department of Step Ltd. (Scientists and Technologists Engineering Partnership Ltd.), Abbey House, Victoria-street, London, S.W.1.

MR. T. S. KILPATRICK, director and commercial manager of the Workington Iron and Steel Co., has been appointed a director of the Distington Engineering Co. Ltd. As from May 3, he is commercial manager of both companies.

DR. J. M. COULSON, A.M.I.Chem.E., reader in chemical engineering at Imperial College, has been appointed to the Chair of chemical engineering, King's College, Newcastle-upon-Tyne, and will commence his duties on October 1.

MR. I. H. HEDLEY, B.Sc., M.I.E.E., has joined the staff of the Hackbridge and Hewittic Electric Co. Ltd., Walton-on-Thames, Surrey, as technical adviser and sales representative in Northern England and the Midlands.

MR. M. M. HALLETT, M.Sc., F.I.M., has been appointed director of research to three Sheepbridge Group Companies, namely, Sheepbridge Stokes Ltd., Chesterfield, Sheepbridge Equipment Ltd., Chesterfield, and Sheepbridge Steel Castings Ltd., Sutton-in-Ashfield, Nottinghamshire.

MR. W. D. WILSON, M.I.P.E., general manager of the Grantham Works of Newman Industries Ltd., Yate, Bristol, has been elected to the board of the company.

MR. A. J. BUDD, B.Sc.Tech., has been appointed assistant superintendent, Leonard Works, of Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17.

MR. ALAN GRANT has been appointed manager of the sales department (cable estimating) of Johnson and Phillips Ltd., Charlton, London, S.E.7.

MR. E. F. JOHNSON has been appointed sales manager to Cimex-Fraser Tuson Ltd., manufacturers of mechanical floor-cleaning machines, Orpington, Kent.

MR. J. S. DICK has been appointed Scottish-area manager to Macrome Ltd., Aldersley, Wolverhampton. He will operate from the firm's new office in Central Chambers, 11 Bothwell-street, Glasgow, C.2.

MR. G. P. COLE has been appointed area representative for Gloucestershire, Somerset and S. Wales of W. H. Heywood & Co. Ltd., Bayhall Works, Huddersfield. His office is at Cornwall House, The Promenade, Bristol (Telephone: Bristol 38324). MR. H. PENNINGTON, Exchange Buildings, Sefton House, Liverpool (Telephone: Liverpool Central 4214) is the firm's representative for S.W. Lancashire, S.W. Cheshire, N. Staffordshire and N. Wales.

BUSINESS CHANGES

THE HAWKER SIDDELEY GROUP have purchased CANADIAN STEEL IMPROVEMENT LTD., Etobicoke, North Toronto, Canada, in order to further their interests in titanium.

GLOBELITE INDUSTRIES LTD., a subsidiary company of SOUTHERN AREAS ELECTRIC CORPORATION LTD., have moved into their new factory on the Marsh Barton Estate, Exeter.

THE MORSE CHAIN CO. LTD., in conjunction with their West Midlands representatives, W. LEWTHWAITE & SONS LTD., are opening a West Midlands stock depot at Belmont House, 15 Belmont-row, Birmingham, 4. (Telephone: Aston Cross 3751.)

DAVID BROWN TRACTORS (ENGINEERING) LTD., Meltham, Yorkshire, have concluded an agreement with BOOTH, MACDONALD & CO. LTD., Christchurch, N.Z., whereby the latter firm will assemble David Brown implements, which in the first instance, will be shipped in the completely knocked down condition from the U.K., commencing in August.

In an entry in this column on page 485 of our issue of April 16 we referred to an agreement whereby Wiggins Hidek and Lodek floating roof structures are to be manufactured by ASHMORE, BENSON, PEASE & CO., Stockton-on-Tees, and stated that this firm are the proprietors of the POWER GAS CORPORATION LTD. We regret this error, as, of course, the contrary is true, the Power Gas Corporation being the proprietors of Ashmore, Benson, Pease & Co.

Following the formation, in January, of BALFOUR, BEATTY & CO. (CANADA) LTD., the Canadian subsidiary of BALFOUR, BEATTY & CO. LTD., the Canadian company have taken over the assets, liabilities and personnel of RUSSELL CONSTRUCTION CO., LTD., Toronto, and will continue to operate the firm as RUSSELL CONSTRUCTION LTD.

OBITUARY

We regret to record the deaths of the following:

MR. WILLIAM PATERSON SNEDDEN, A.R.T.C., on April 23, at the age of 55. He had been chief technical engineer, rolling-mill and steelworks division British Timken Limited, Duston, Northampton, since 1943. He served his apprenticeship with Lamberton and Company, Limited, Coatbridge, Lanarkshire, after which he was appointed rolling-mill engineer successively to the Ebbw Vale Steel Coal and Iron Company, Limited; Dorman, Long and Company, Limited; and Richard Thomas and Baldwins, Limited. He was elected a member of the Iron and Steel Institute in 1935.

COMMODORE THOMAS MCKENZIE, C.B., C.B.E., R.N.V.R., on April 25 at his home in Shandon, Dumbartonshire, at the age of 62. He was a director of Metal Industries, Limited, and managing director of Metal Industries (Salvage), Limited, Faslane, and commenced his salvage career in 1911, on completion of his shipbuilding apprenticeship. He served with the Admiralty Salvage Department from 1915 until 1919, and was chief salvage officer on the raising of the ex-German fleet at Scapa from 1924 to 1932 and again from 1933 to 1939. Then in the latter year he was appointed Admiralty Chief Salvage Officer.

EUROPEAN COAL AND STEEL COMMUNITY

Results of First Year of Common Markets

As stated in our issue of March 12, on page 324, the main results of the establishment of the European Coal and Steel Community have been the creation, as from February 10, 1953, of a common market for coal, iron ore and scrap, and, from May 1, 1953, for steel, across the frontiers of Belgium, France, the German Federal Republic, Italy, Luxembourg and the Netherlands. This step has eliminated many trade barriers, including customs duties, quantitative restrictions on imports and exports, double pricing, transport discriminations, and restrictions on the allocation of currency for trans-frontier commerce.

The Community is administered by a High Authority or international executive council of nine members. Attached to this is a consultative committee of 51 members, drawn in equal numbers from among the producing and consuming organisations of the Community and their employees. The High Authority is responsible and submits reports to the Common Assembly which consists of 78 members elected annually by the Parliaments of the nations concerned. In cases of controversy and in response to appeals, a Court of Justice of seven judges makes pronouncements on whether the decisions of the High Authority are in conformity with the Treaty instituting the Community. Finally, a Council of Ministers, one from the Government of each of the six member States involved, " harmonise states policies with that of the Community."

The second annual report of the High Authority to the Common Assembly has now been issued. It covers the twelve months from April 13, 1953, to April 11, 1954, and will be debated at meetings of the Common Assembly which are to commence at Strasbourg, France, on May 11. It is pointed out in the report that the common markets have now been in existence for about a year and that the contents of the report, therefore, constitute a " balance sheet " of the first results achieved by the Community.

The increase in the trade in coal has been remarkable; thus in the year 1953 the commerce in hard coal (as opposed to lignite) among the countries of the Community increased by about 3·5 million metric tons, or 22 per cent., as compared with 1952, in spite of a decline of 5 per cent. in consumption due to general economic conditions. Significant increases have also taken place in the trade in steel, following a period of adjustment, but as the common market for steel was set up, as stated above, only on May 1, 1953, it has been considered preferable to draw comparisons between monthly averages for the first six months of 1953 and those for the third and fourth quarters of the year. In the first half of 1953 the monthly volume of deliveries of iron and steel products from country to country in the Community was 194,300 metric tons. In the third quarter it was 170,100 tons, and in the last, 240,500 tons.

Quantitative restrictions on exports of French iron ore, the production of which represents more than two-thirds of the total output of the countries in the Community, were abolished on February 10, 1953. As a result, there was an immediate increase in deliveries to other member countries, particularly Belgium and Luxembourg. During 1953, the French iron-ore mines delivered to these two countries over nine million metric tons of iron ore, or 10 per cent. more than in 1952. As a result, the Belgian iron and steel industry was able to limit its consumption of scrap.

The free movement of scrap within the common markets was put into effect on March 15, 1953, and at the same time maximum prices were fixed for this commodity. Immediately the purchases of scrap by consumer countries from other countries in the Community rose sharply from 36,000 tons a month in 1952 and 39,300 tons a month in the first quarter of 1953, to 60,000 tons a month in the second and third quarters, and 160,000 tons a month in the last quarter of 1953.

* * *

BRITISH IRON AND STEEL FEDERATION

Activities in 1953

The year 1953 was one of expanding production in the British steel industry. Not only were adequate supplies of raw materials available but a good deal of new plant was placed in service as the result of the completion of the first post-war development plan and the launching of the second plan. In these circumstances the industry achieved a record steel output of 17·6 million tons or about 1·5 million tons higher than the rate for 1952. It is pointed out in the recently-issued annual report for 1953 of the British Iron and Steel Federation, Steel House, Tothill-street, London, S.W.1, that the high level of production made possible an increase of supplies to the home market and the removal of distribution control. Moreover, steel imports were reduced from 1·8 million ingot tons in 1952 to 1·1 million tons in 1953, while steel exports rose from 2·6 million ingot tons two years ago to 2·8 million tons last year.

The expansion of production was accompanied by a further increase in productivity, the index of output per head in steel melting and rolling rising by 4 per cent. during the year. The rise in productivity helped to offset the increase which took place in home costs.

The passage of the Iron and Steel Act, 1953, has led to the establishment of the Iron and Steel Board, and this has resulted in a number of changes in practice and procedure. Thus the Board has taken over the responsibility for price control from the Minister of Supply and has also assumed the responsibility for the collection, from firms, of information relating to costs. The plant-progress department of the Federation, which operated in part on behalf of the Ministry of Supply, has been transferred to the Board. The Ministry of Supply has ended the arrangement by which the Federation, acting on behalf of the Ministry, has collected statistics relating to iron and steel foundries, and the collection of these, henceforth, will be undertaken by the Board. It has also been agreed that the Board shall publish monthly figures of pig iron and steel production, while the Federation will continue to publish its Monthly Statistical Bulletin containing detailed information relating to the industry.

The number of persons employed in the industry, including those engaged in iron-ore mines and quarries and at coke ovens, together with general and maintenance employees and administrative, technical and clerical grades, was 310,113. The average weekly hours worked were 46·4 and the average weekly earnings £9 19*s*. The traditionally good labour relations in the industry were maintained; and there were further developments in the industry's training arrangements, including the expansion of residential courses for managers and foremen. A special report on the problem of accident prevention has been completed. Its most important conclusion is that, contrary to general belief, accident prevention is not primarily a technical matter. The report stresses that accident prevention must be the responsibility of all executive managers, and that what is required is a positive attitude to work rather than a negative attitude towards danger. The value of planned training in creating the right attitude towards accident prevention is also emphasised. As a result of the recommendations of the report, a standing Accident Prevention Committee, under the chairmanship of Mr. R. F. Summers, has been set up to co-ordinate action in this field.

* * *

PROGRESS IN ELECTRICAL RESEARCH

A Year's Work in Many Fields

The thirty-third annual report of the British Electrical and Allied Industries Research Association, for the year ended December 31, 1953 (which was published last week), gives a detailed account of the useful work this body is doing in a number of fields. It records that the main efforts in those researches which concerned generation were still in the domain of high-temperature alloy steels. They included tests on long-term creep and relaxation, which must last from 10,000 to 30,000 hours and which are of importance in connection with plant that is already being ordered. This work, which is being continued during the present year, received support from the British Iron and Steel Research Association, as well as from the turbine, boiler and tube manufacturers.

WIND POWER

During 1953 the Association continued its co-operation with the North of Scotland Hydro-Electric Board, the British Electricity Authority, and the manufacturers on the 100-kW wind generator in operation in Orkney, and the similar set which will probably be erected in Wales. The wind survey of the British Isles approached completion, apart from work on sites selected for generators. It is mentioned, as a matter of interest, that the highest wind speed recorded in the British Isles, 125 m.p.h., was measured on the Association's equipment at Costa Hill in Orkney. Work was continued on the direct electrochemical production of electric power and the investigators made significant progress in overcoming the corrosion of the oxygen electrode which has so far limited the life of the cell.

TRANSMISSION PROBLEMS

The possibility of transmitting direct current at high voltage over the fourth (spare) cable, which might be included in the proposed link between the British and French systems, was considered. Some tests were made on a submarine cable to the Isle of Wight to ascertain the possible effect of magnetic fields on navigation. The use of series capacitances to improve the regulation and stability of long overhead lines is hampered by the damage that may take place when accidental short-circuits occur.

In order to obtain a correct interpretation of circuit interruptions caused by lightning, some knowledge of the attenuation of surges with distance is essential. The tests which were made many years ago on high-voltage lines mounted on steel poles, were extended during the year to an 11-kV line carried on wood poles. The Association further pursued its improvements to the alternating-current air-break arc chute type of circuit-breaker by means of high power tests.

Similar tests were also made on the measurement of post-zero current in an alternating-current arc broken by an experimental gas-blast circuit-breaker. As part of the general investigation of thermal problems in transformers, a device was developed for measuring ambient temperature in such a way that the results accurately reflect the effect of the variation of that temperature on temperature rise.

RURAL ELECTRIFICATION

Work was continued on rural electrification with the support of the Ministry of Agriculture and Fisheries. Apart from the researches on crop drying, during which a simple moisture meter was developed, the success achieved with portable electric weed killers on seedlings led to a larger experiment on killing bracken. The year's work confirmed the advantages of artificially illuminating tomato seedlings and the promising results obtained with high-frequency methods of destroying weevils in stored grain led to the study of higher frequencies.

In a more fundamental field, theoretical and experimental studies of ferro-electrics led to a better understanding of structural transitions and the behaviour of poly-crystalline materials. Although the work on possible new ferro-electrics was negative, it formed an important contribution on the relation between semi-conducting and ferro-electric properties.

INDUSTRIAL INSULANTS

Work on industrial insulants during the year included the study and testing of varnish fabric (particularly glass fabric), fabric and plaster sleevings for heavy plant, tracking of varnish and other impregnants or finishes, cotton-covered wire (where the lubricants in spinning had been found to have an effect) and insulating films based on silicones, polytetrafluorethylene and polymonochlortrifluorethylene. Special attention was also paid to insulating oils in connection with the use of inhibitors, maintenance, oxidation and saponification, copper contamination and both the intrinsic and industrial electric strength, including the effect of pressure.

In September, 1953, the Department of Scientific and Industrial Research notified the Association that the Government were prepared to make a grant of up to £100,000 towards the cost of new buildings at Leatherhead. This grant was subject to a number of conditions, the most important of which were that the Association should meet £100,000 of the cost from its reserves before any Government grant was spent and that the total capital contributions paid by or guaranteed from members should reach £200,000. This sum has nearly been reached and a contract for the building was sealed in November.

* * *

MOTOR INDUSTRY SCHOLARSHIPS

A four-year residential diploma course for the motor industry will be inaugurated at Loughborough College of Technology next September, under the auspices of the Institute of the Motor Industry. In this connection, the Institute announces that at least eight scholarships will be available, each of which will carry a grant of £150 a year.

Two of the scholarships have been presented directly by the Institute and one of these will be known as the "Stanley S. Dawes Scholarship," in commemoration of the services of the Institute's President to its work and to the establishment of the course.

Further particulars of the course may be obtained from the Institute, 40 Queens-gate, London, S.W.7, but all applications must be addressed in the first instance to the Registrar, College of Technology, Loughborough.

THE INSTITUTE OF FUEL

Sir Christopher Hinton on Atomic Power as Alternative Fuel

The annual luncheon of the Institute of Fuel was held at the Connaught Rooms, London, W.C.2, on April 29, the chair being taken by the President, Dr. W. Idris Jones. The principal guest was Sir Christopher Hinton, Deputy Controller of Atomic Energy (Production), Ministry of Supply. Among the other guests of the Institute were the Hon. W. Walton Butterworth, representing the United States Ambassador (His Excellency the Hon. Winthrop W. Aldrich), the Rt. Hon. Lord Citrine, P.C., chairman of the British Electricity Authority, and Dr. E. D. Adrian, O.M., President of the Royal Society.

The loyal toast having been honoured, the President announced that the Council had awarded the 24th Melchett Medal to Dr. Henry Herman Storch for his distinguished work as a member of the United States Bureau of Mines, especially as Chief of the Synthetic Fuels Branch of the Bureau. In handing the Medal to Dr. Storch, Dr. Idris Jones recalled that it was the third Melchett Medal to be awarded to an American fuel technologist, the previous recipients being the late Charles M. Schwab, of the Bethlehem Steel Corporation, in 1932, and Dr. Arno C. Fieldner, of the United States Bureau of Mines, in 1942. Dr. Storch, he added, would be delivering his Melchett Lecture later in the year.

The only other toast was that of "The Guests," proposed by the President. Sir Christopher Hinton, in responding, indicated some of the future possibilities latent in the development work now being undertaken in the application of atomic energy to industrial uses, emphasising that properly it should be regarded as an alternative fuel to those hitherto employed; but with the essential difference that, while conventional combustion was easily started, atomic changes were more difficult to start and to stop. With all its problems, however, atomic energy offered immense advantages over ordinary fuels. The coal resources of the United Kingdom would not last much more than 200 years. Moreover, the hydrocarbons commonly used as fuels were the most important sources of chemical raw materials. It was an urgent duty, therefore, to develop alternative fuels and to conserve the hydrocarbons.

The problems which confronted atomic engineers, Sir Christopher continued, were no more difficult in proportion than those which faced the pioneers of the steam engine; the chief trouble was that some parts of an atomic plant, once used, could not be approached by human beings at any future time. Those problems, however, were largely solved so far as design was concerned, and their solution had been reduced to what might be termed a "bread-and-butter technique." The prospects were promising. The atomic piles now under construction represented only a first step in the production of electrical power. They should be able to produce current at a penny a unit, a cost which was about twice that of the best thermal power stations. Capital costs were largely responsible for this relatively high rate; but capital costs always fell with improved experience, and the cost of atomic power should fall also. The cost of coal, on the other hand, would certainly continue to rise, so that, in ten to 15 years, it should be possible to build atomic plants that could compete with thermal stations. To do this, however, the engineering industry must be increasingly drawn into collaboration. The national team would have to do the pioneer work, but the industry must apply it and construct the industrial plants – always bearing in mind, he repeated, that nuclear power was simply an alternative fuel.

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ANNUAL DINNER OF THE I.C.E.

Engineers' Gifts to Posterity

The annual dinner of the Institution of Civil Engineers took place at the Dorchester Hotel, London, on April 29. Mr. D. M. Watson, vice-president, was in the chair, the President (Mr. W. P. Shepherd-Barron) attending the opening of the Owen Falls scheme.

The toast of "The Institution of Civil Engineers" was proposed by Sir John Maud, Permanent Secretary, Ministry of Fuel and Power, who said that, although not an engineer himself, he believed in engineers. He even believed in scientists. Above all, however, he believed in the alliance of engineers, scientists, artists, administrators and bureaucrats like himself, being of the opinion that between them they could do something which none of them could do alone. The world was more cheerful with engineers. Without them it would be nasty, brutish and short.

Civil engineers had a better chance than most of leaving something behind them which would testify to what they did when they were alive. Because atomic energy for industrial purposes might in ten years' time help to supplement our present resources there was no excuse for wasting coal. Water, too, was another of the resources of nature of which civil engineers were the stewards. The Institution was, in fact, an outstanding example of a great professional body which over the years had proved it was worthy of the secrets that scientists and engineers had wrested from nature, and it was to them that society should look to make it more likely that in future we were worthy of the secrets that would be revealed.

In reply, the chairman said that the numbers of members of all classes continued to rise satisfactorily, and there were now 2,500 graduates, compared with 1,500 a year ago. He paid a tribute to the memory of Mr. Graham Clark who had served the Institution for 40 years, during 16 of which he had been secretary. It was hoped that it would be possible to obtain a portrait of him to hang in an honoured place.

The toast of "The Guests" was proposed by Mr. H. F. Cronin. The Very Rev. A. C. Don, Dean of Westminster, replied.

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HOROLOGY AWARD

The Worshipful Company of Clockmakers has decided to institute an award for outstanding achievement in the field of horology. This will take the form of a gold medal, to be known as the Tompion medal of the Worshipful Company of Clockmakers, and will be awarded not more than once in any one calendar year, without regard to the nationality of the recipient. In making this announcement at a Press conference held in London on Monday, April 26, the Astronomer Royal (Sir Harold Spencer Jones) said that the Company, which had first received its charter in 1631, had always maintained a close connection with the craft of clockmaking. Tompion was perhaps the most famous of its Masters and his tomb in Westminster Abbey bore the statement that he was "inspired with a secret wish to excel." It was fitting that his name should be associated with what was intended to be an international award.

THE INSTITUTE OF METALS

MEETING WITH SOCIÉTÉ FRANÇAISE DE MÉTALLURGIE

The forty-sixth annual general meeting of the Institute of Metals, which opened on the evening of Monday, April 26, in the lecture theatre of the Royal Institution, London, took the form of a joint spring meeting with the Société Française de Métallurgie. This is the first occasion on which the Institute of Metals (or, so far as is known, any British metallurgical society) has acted as host in the United Kingdom to a foreign metallurgical society. The chair was occupied by the President, Professor F. C. Thompson, who welcomed the members of the Société on behalf of the Institute of Metals and in doing so referred to the hospitality received by British metallurgists at the most successful meetings held by the Institute in Paris, in 1936 and 1949. Professor Sir Cyril Hinshelwood, F.R.S., Foreign Secretary of the Royal Society, who welcomed the members of the Société on behalf of British scientists paid tribute to the contributions made to the science of metallurgy by French investigators. He hoped that the present meeting of the two societies would be helpful both from the practical and the theoretical points of view. In returning thanks for the speeches of welcome, Dr. E. L. Dupuy, the President of the Société, said that this was the first occasion on which they had held a meeting abroad. They were particularly glad to be in England because ferrous as well as non-ferrous metallurgy and metallurgical science owed so much to Great Britain.

After the opening ceremony, Professor L. F. Bates, D.Sc., F.R.S., Lancashire-Spencer Professor of Physics in the University of Nottingham delivered the 44th May Lecture on "The Domain Structure of Ferromagnetic Metals." The lecture will be found on page 590 of this issue.

On the morning of Tuesday, April 27, Professor F. C. Thompson, the retiring President, again occupied the chair. After the minutes of the last general meetings and other preliminary business had been dealt with the secretary announced that, by invitation of the Swiss Association of Machinery Manufacturers and the Swiss Association for Testing Materials, the 1954 Autumn Meeting of the Institute would be held in Zürich.

REPORT OF COUNCIL

The report of Council for the year ended December 31, 1953, was then presented. This showed that the number of members on the active list of the Institute was 4,168 at the end of 1953, compared with 3,948 on December 31, 1952 and 3,727 on December 31, 1951.

ELECTION OF OFFICERS

The officers nominated by the Council at the autumn meeting held in Southport, Lancashire, on September 21, 1953, were declared to be duly elected for the year 1954-55. They were: as President, Dr. S. F. Dorey, C.B.E., F.R.S.; as vice-presidents, Dr. Maurice Cook, Dr. C. B. Pfeil, O.B.E., F.R.S., and Major P. L. Teed; and as ordinary members of Council, Mr. R. D. Hamer and Mr. C. P. Tinker. The members were also reminded that, last autumn the Council had elected Dr. Maurice Cook as senior vice-president for the year 1954-55, and that he would be the Council's nominee for the Presidency in 1955-56. A vote of thanks to the retiring officers, namely, Mr. H. S. Tasker, past-president, and Mr. A. B. Graham and Mr. P. V. Hunter, C.B.E., vice-presidents, was then proposed and carried.

On behalf of the directors of Johnson, Matthey and Company, Limited, Mr. Donald McDonald, joint managing director, presented to the Institute a Presidential badge of office and also the grant of Arms made by the College of Heralds to the Institute. He invested the President with the badge, which is suspended from a blue ribbon, and the President thanked Mr. McDonald and his firm for their generosity.

INDUCTION OF NEW PRESIDENT

Professor Thompson then said that the time had come for him to lay down his office. During his year in the Presidency he had been particularly impressed by two things, the first of which was the really good work which the local sections were doing and, secondly, the great importance to the Institute of the metallurgical engineering committee. This committee had done much to dissipate the view that the Institute was devoting too much time and too many of its resources to the fundamental aspects of metallurgical research.

On handing over the Presidential badge to his successor in the chair, Dr. S. F. Dorey, C.B.E., F.R.S., Professor Thompson said that Dr. Dorey was an engineer of the very highest reputation and the possessor of a wide experience. His reputation as an engineer, however, could not have been built up were it not for the fact that he knew a great deal concerning the properties of metallic materials and, in particular, how they stood up under a wide range of service conditions.

The new President's first duty was to call on Dr. Ivor Jenkins to propose a vote of thanks to Professor Thompson for his service as President during the year 1953-54. This was seconded by Dr. R. J. Parker and carried, after which Dr. Dorey delivered his presidential address. In this, he made a survey of the metals and alloys used in marine engineering. We reproduce Dr. Dorey's address on page 589.

AWARD OF MEDALS

The secretary then announced that the Institute of Metals Platinum Medal for 1954 had been awarded to Dr. Leslie Aitchison, honorary member, in recognition of his services to metallurgy in industry, in education and in public services. In presenting the Medal, Dr. Dorey recalled that Dr. Aitchison had established the Chair of Industrial Metallurgy at the University of Birmingham but had had to relinquish it subsequently owing to ill health. He had also long been associated with metallurgical research in connection with aeronautics.

The Rosenhain Medal for 1954 was awarded to Professor A. H. Cottrell, who holds the Chair of Physical Metallurgy at the University of Birmingham, in recognition of his outstanding contributions to knowledge in the field of physical metallurgy, with special reference to the deformation of metals. Finally, the students' essay prize for 1953 was presented to Mr. Derek Hull, student member, of the Department of Metallurgy, University College, Cardiff, for an essay on "The Characteristics of the Martensite Transformation," which had been recommended for publication in the Institute's *Bulletin*.

To be continued

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Letters to the Editor

HIGH-TEMPERATURE STEAM PIPES

Properties of Steel and Basis of Design

SIR, Mr. P. H. Margen's article in ENGINEERING of April 9 (page 457) gives an interesting review of current data on the subject of creep and the design of high-temperature steam pipes. There are, however, a number of points which merit comment.

Mr. Margen speaks somewhat scathingly of B.S.806:1954, and refers to it as a British Standard Piping Code. It is, in fact, not a Code, but a British Standard, and does not purport to assist the designer of new high-temperature power stations but, as in all other Standards, attempts to correlate existing good practice.

In ENGINEERING for October 30, 1953 (page 549), a somewhat similar article appeared over my name, and it is interesting to see that Mr. Margen agrees almost entirely with the views which I then put forward; namely, that in cases where creep is the primary consideration, the thin-cylinder formula should be used and the stresses should be based on the creep rupture characteristic rather than the creep elongation characteristic of the material. I also pointed out that scaling allowances were required.

As a result of my article I had hoped that new data would come forward for creep characteristics of the various high-temperature steels, but unfortunately Mr. Margen's article does not contain anything new in this respect, the data having been published in various forms previously.

Mr. Margen frequently refers to an allowance for corrosion, which seems a rather curious name for what is, in fact, scaling at the high temperatures to which these materials are subjected.

I am glad to see also that he agrees with my contention that there is no need for a gradual transition from Barlow's formula to the thin-cylinder formula, but that the steels for higher temperatures (say, over 975 deg. F.) should be designed solely on a creep basis.

Where I think we differ most is in regard to the suitability of the molybdenum-vanadium steel. Not only does Mr. Margen show that it is a stronger material on the basis of considerably extrapolated tests, but he assigns a smaller rupture safety factor to it than that which would be used with, for example, 2¼ per cent. chromium/1 per cent. molybdenum steel.

As I pointed out in my article, it is essential for this type of design that the steel should show considerable ductility. It is not the general overall elongation which matters, but the local elongations which may take place at stress raisers, sharp corners, etc., and in this respect it is questionable whether molybdenum-vanadium steel shows sufficient ductility before rupture to make it a satisfactory material, however good its apparent creep resistance may be.

The final allowable working stresses, though not quite the same, are not very different from those which I would suggest for the materials most likely to be suitable for this type of application, but it should be remembered in this connection that the British Standards Committee which produced B.S.806 are fully alive to the necessity for further extension of the Standard and have in hand the consideration of the design basis for high-temperature materials, and will later lay down formulae, stresses, scaling allowances, etc., for the appropriate conditions.

Yours faithfully,
J. S. BLAIR.

Stewarts and Lloyds, Limited,
Corby, Northants.
May 3, 1954.

SIR, May I draw attention to the fact that Equation 5 in my article "High Temperature Steam Pipes" was written incorrectly. The correct form is:

$$(1 + a_1) = \left\{\Sigma h \left(\frac{P}{P}\right)^n [1 + g\,(\theta - \Theta)]^n\right\}^{\frac{1}{n}}$$

where $-n$ = the gradient of the log time/log rupture stress curve.

Yours faithfully,
P. MARGEN.

12, Caxton-street,
London, S.W.1.
April 27, 1954.

RESEARCH ON WATER POLLUTION

TREATMENT OF RADIOACTIVE EFFLUENTS

The report* for the year 1953 of the Director of water pollution research is prefaced by a short report from the Board signed by Professor D. M. Newitt, the chairman. In this it is stated that the new laboratory at Stevenage is likely to be ready for occupation in the course of this year. The inadequacy of the present premises in Watford has for long hampered the work of the laboratory and has probably increased its administrative cost. The undertaking of desirable investigations has also had to be postponed or declined. Professor Newitt remarks that it has been thought wise to concentrate on a few projects, notably on the survey of the Thames Estuary, until substantial progress has been made with those in hand, or until further staff becomes available. No doubt the greatly increased accommodation which will be provided at Stevenage, will enable such further staff to be effectively employed.

The survey of the Thames Estuary, to which Professor Newitt particularly refers, is the subject of the longest section of the Directors' report. This survey was started in 1948, and in the Boards' report for that year it was remarked that " it is probable that the investigation will occupy at least three years." There is no suggestion in the present report that the survey was nearing its end in 1953. The work which is being carried out for, and in conjunction with, the Port of London Authority is designed " to provide information on which a considered policy for the future of the estuary can be based." Examples of what it is desirable to ascertain are the extent to which sewage and trade wastes should be purified before discharge to the estuary and the extent to which the temperature of the river water may be allowed to rise as a result of condenser-water discharges from power stations.

Information about the whole series of investigations to which the survey has led can be obtained only by a study of the Directors' report. The matters dealt with include a stastical examination of the records of the condition of the Thames which have been made available by the London County Council. The records go back to the year 1920 and include the results of 95,000 analyses. Other matters concerned are the rate of oxidation of polluting matter, the nature of bottom deposits, the reduction of sulphate to sulphide and the concentration of suspended solids.

DISCHARGE FROM POWER STATIONS

Two of the matters concerned are of direct engineering interest. A survey covering the past few years indicates that the heat units discharged to the river from power stations constitute 73 per cent. of the total; industrial effluents contribute 10 per cent. and sewage effluents 9 per cent. The heat in discharged condenser water from power stations has, for the past 20 years, been increasing at an average rate per year of about $6{\cdot}7 \times 10^9$ B.Th.U. per day and it is considered that the rate of increase over the next 10 years is likely to be at least as great. The other matter of mechanical-engineering interest concerns the corrosion of ships' propellers, probably by sulphide. This matter was the subject of a letter from two members of the Laboratory staff, which appeared in our issue of April 24, 1953.

* *Report of the Water Pollution Research Board with the Report of the Director of Water Pollution Research for the year* 1953. H.M. Stationery Office (2*s.* 6*d.*)

A matter which has been the subject of some public attention, not always based on understanding, concerns the treatment of effluents containing radioactive substances. The actual investigation, carried out at the request of the Ministry of Supply, was made to assess the possibility of removing radioactive material by treating the effluent by the activated-sludge process. The investigation dealt with radio-isotopes iodine 131, strontium 90, ruthenium 106, cerium 144, caesium 134, and plutonium 239. Of these, about 96 per cent. of plutonium was removed, but the result with some other radio-isotopes was less satisfactory; caesium and ruthenium were particularly difficult to remove. The general conclusion is that the activated-sludge treatment of sewage containing small quantities of radio-active substances might remove part of them but could not be relied on to remove the whole.

Potentially, a more important aspect of the question of radio-active pollution is concerned with domestic water supply. Possibly as a result of enemy action, or even by discharge for industry, hospitals or research establishments, water sources might become contaminated, and it is of importance to know if the usual treatment methods employed at a water works would remove radio-isotopes. Broadly, the results so far obtained indicate that the normal filtration and chlorination treatments practised at water works will not remove all radioactive isotopes likely to be present in water contaminated as a result of an atomic explosion, although a comparatively high proportion of some isotopes will be removed. The present report deals particularly with work directed to the removal of radio-strontium, " one of the most dangerous of the possible contaminants of water supplies."

INDUSTRIAL EFFLUENTS

Much of the work of the Water Pollution Research Laboratory has from the first been concerned with the treatment of industrial effluents. The present report deals with waste waters containing cyanide and with further experiments on the treatment of waste water from the kiering of cotton, a subject which was dealt with in the report for the year 1952. Of these two matters, that concerning cyanide is the one of interest to many engineers. In the report for 1952, reference was made to a small plant built by the Ministry of Works to treat waste quenching water from a cyanide hardening plant at a Ministry of Supply depot. The method used depends on the treatment of the waste water with chlorine in a strongly-alkaline solution. The present report refers to and reproduces a photograph of a large plant which has been installed at a " motor engineering works." No detail description is given, but it is stated that the plant treats 20,000 gallons of waste water per day and is working very satisfactorily.

As is usual in these reports, information is given about investigations concerned with various aspects of sewage treatment, biological filtration, in particular, being dealt with. This matter cannot be briefly summarised, but there are two associated questions which may be mentioned; they may become of increasing importance as a result of present day housing developments. The first concerns the performance of small sewage plants serving small groups of houses. Investigation showed that such plants, usually consisting of a septic tank and a percolating filter, could perform satisfactorily but the importance of proper maintenance is emphasized. The second matter relates to housing estates drained on the " separate system," that in which surface waters from roofs and paved areas are discharged to soakaways or direct to streams. An investigation has been started at the Oxhey Estate of the London County Council, where collecting and automatic sampling apparatus has been installed. The records have not yet been examined in detail, but the concentration of suspended solids has been found to be high and the first flush at the beginning of a storm was highly polluting. The observations are continuing.

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AGRICULTURAL PNEUMATIC TYRES

Radio Isotopes for Measuring Wear

The Dunlop Rubber Company, Limited, Fort Dunlop, Erdington, Birmingham, 24, celebrated the 21st birthday of the agricultural tyre on April 26, with a luncheon and Press visit. The Dunlop agricultural tyre is claimed to have been the first ever made. It was originally known as the horse-vehicle tyre and was made as the result of suggestions from two Scots, Mr. James Gilmour, then farming at Sutton Coldfield, and Mr. John Lockhart, who farmed the land at Fort Dunlop. Both were present at the luncheon.

In 1933 Dunlop's pneumatic land-wheel equipment was awarded the silver medal in the new-implement section at the Highland Show, Dundee, and the Royal Show, Derby. In the same year, Britain's first practicable pneumatic agricultural-tractor tyres were issued to farmers for full-scale tests and one of the earliest users was Mr. Harry Ferguson, the present-day tractor manufacturer. Actually the very first agricultural pneumatic tyre was said to have been fitted in 1929 to the wheelbarrow of one of the gardeners at Fort Dunlop.

A tour of the company's research centre preceded the luncheon and some recent developments were on show. Radio-active isotopes are being used to measure the wear on tyres during road tests. The isotopes are put into the tyre by immersing part of the cover in a solution of radio-active liquid. The amount of radioactivity present before and after a 100-mile test is measured by a Geiger counter and monitor. From the results the rubber lost is calculated. This method has been adopted because it enables a very small amount of wear to be detected, whereas longer runs are required if the " loss of weight" method is used.

Another test in progress was the freezing of aircraft tyres followed by landing-impact tests. The object was to find the best material for operation in low-temperature conditions. A synthetic rubber has been made which, early tests indicate, gives a better performance than natural rubber.

By adding carbon to the rubber a material which will not hold a charge of static electricity has been produced. It will be used for bus tyres and also in hospital rubber-ware to eliminate the risk of explosion of an anæsthetic due to a static spark.

Exhibits of general interest were barrows, buckets, factory containers, dustbins and lawn-mower boxes, made from a material consisting of natural rubber reinforced by a phenolic type of resin. Two aircraft tyres were also seen undergoing landing tests on the rig which was described in ENGINEERING, vol. 174, page 787 (1952).

BOOK REVIEWS

Electrical Earthing and Accident Prevention. Edited by DR. M. G. SAY. *George Newnes, Limited, Tower House, Southampton-street, London, W.C.2.* (25*s.*)

This book consists of a preface by the Editor and ten sections, or chapters, which together review every aspect of the subject of electrical earthing. The sections, the work of 19 specialist contributors, deal with power-system, domestic and industrial earthing; ship, electric-traction, mining and aircraft installations; and the special cases of portable apparatus, machine tools, electronic and electromedical equipment and lightning protection. This list, which is not quite complete, indicates the wide variety of conditions which have to be provided for by rules and regulations designed to insure adequate earthing.

In itself, the provision of a connection to earth may appear a simple matter, but its maintenance may prove quite otherwise. An earth, or rather, sea, connection in a ship may present no difficulty, but the salt-laden atmosphere may require that particular attention should be paid to the possibilities of corrosion. Similarly, earth plates, frequently difficult, or impossible, to inspect, have been known to be completely eaten away. Connection to water pipes, common with domestic installations, may fail to provide a reliable earth owing to the substitution of cement-asbestos pipes in place of those of metal. Water supply authorities are under no obligation to provide electrical earth connections.

A section of this book reviews the various official regulations which are in being and relate to the subject. Regulations may specify proper installation arrangements but cannot ensure adequate maintenance. Bearing on this point, Mr. H. W. Swann, who contributes the first section, remarks that the Electricity Supply Regulations state that impedance shall not be inserted in the neutral-earth connection of a supply transformer, but do not say that it shall be removed if it gets there without being "inserted."

The subject of electrical earthing is by no means covered by consideration of the physical nature of the actual earth connection. It has two, possibly equally important, divisions – system earthing and equipment earthing. Both are fully dealt with in this book, the information in which ranges from the use of resistance, reactance and arc and arc-suppression coil earthing for high-voltage power systems, and the arrangements appropriate for rural lines, to the earthing of domestic apparatus. In connection with the latter, although each year provides records of a number of distressing electrical accidents, the total is small compared with the number of appliances in use. Mr. T. C. Gilbert, who provides the section dealing with domestic earthing, expresses the opinion that "the greatest hazard in domestic premises is the possibility of fire caused by un-isolated earth leakage flowing over inadequate earthing arrangements".

The provision and maintenance of proper system earthing is a matter for supply authorities with skilled advice at their service. Equipment earthing, although not entirely a matter for the consumer, particularly the domestic consumer, is nevertheless to a considerable extent a matter for the user. This is definitely the case in many industrial applications, and sections of this useful book, which should be of value to many works engineers, deal in detail with the earthing of portable apparatus, machine tools, arc-welding plant and electronic equipment.

A Critical Survey of Brittle Fracture in Carbon Plate Steel Structures other than Ships. By M. E. SHANK. Prepared for the National Research Council's Committee on Ship Structural Design. *The Welding Research Council of the Engineering Foundation, 29 West 39th-street, New York 18, N.Y., U.S.A.* (2 dols.)

The serious and spectacular fractures which have occurred at sea and at the dockside in welded ships built during the second World War, brought the problem of brittle fracture in mild steel into sharp focus. Details of these ship fractures which have been collected and studied have yielded valuable information, but until recently no such collection had been made for similar failures in structures other than ships.

Professor M. E. Shank, of Massachusetts Institute of Technology has now prepared a comprehensive collection of information on brittle fractures in structures other than ships. His report shows that the trouble is much more widespread than is generally realised, and is not confined to welded construction. The fractures in non-marine structures are manifestations of the same phenomenon as that which has affected ships, and there is no evidence to show that the percentage incidence of brittle fracture has increased or decreased with the advent of welding. It appears that many fractures which, in the past, have been ascribed to various causes were, in fact, due to notch brittleness of the steel at the prevailing temperature. The cases of brittle fracture which he describes include water standpipes, a gasholder, storage tanks, three Vierendeel truss bridges, a score or so of other bridges, pressure vessels, power shovel booms and dipper sticks, a penstock at the Anderson Ranch Dam, gas transmission lines, a welded steel stack and a methane column. The main value of the report lies in the collection of illuminating facts, but the author also puts forward some views on the general problem of brittle fracture, which are of interest even though controversial.

TRADE PUBLICATIONS

Vibratory Equipment and Magnetic Chucks. We have received from the Magnetic Equipment Co. Ltd., Lake Works, Portchester, Hampshire, two leaflets, one of which illustrates their vibratory feeders and bins, and the other their rectangular and circular all-steel magnetic chucks.

Timekeeping Equipment. Blick Time Recorders, Ltd., 96-100 Aldersgate-street, London, E.C.1, have issued a booklet entitled "How to Reduce Absenteeism by Positive Planning" (2*s.* 6*d.*), compiled by the chairman of the company, Mr. Oswald Moor. It describes several effective methods, both direct and indirect, for encouraging regular attendance and good timekeeping.

Bearing Alloy. High Duty Alloys, Ltd., Slough, Buckinghamshire, have issued a booklet giving the properties of, and design data for, Hiduminium 29, an aluminium alloy for bearings. Hiduminium 29 is suitable for the main and big-end bearing and camshaft bushes in internal-combustion engines, and has also been used successfully in large rolling-mill bearings. It can be supplied in bar and tube form or cast as shells.

Hose Coupling for Air Lines. An illustrated leaflet giving particulars of a light-weight pipe coupling for pneumatic hose lines has been issued by Pneumatic Components, Ltd., Eyre-street, Sheffield.

Automatic Control Equipment. Crosby Valve and Engineering Co., Ltd., Crosby Works, Ealing-road, Wembley, have issued an illustrated catalogue giving specifications of the automatic control equipment for regulating pressure, liquid level, temperature, and flow, that they manufacture under licence from the Mason-Neilan Regulator Co., Boston, U.S.A. The equipment includes pressure-regulated valves, both directly and pilot-operated; controllers, recorders and valve positioners; air-operated control valves; and liquid-level controllers.

Radial-Flow Fans. We have received from Aerex, Ltd., Cavendish Buildings, 220-238 West-street, Sheffield, 1, an illustrated brochure giving specifications and performance curves for their range of Hyperform and Aeroform fans with efficiencies ranging from 85 per cent. to 92 per cent. The Hyperform fans have single plate or lamina section blades, whereas those of the Aeroform are of aerofoil section, and are suitable for applications where very high efficiency is required. The fans are available with impeller diameters ranging from 13¾ in. to 120 in.

Hydraulic Machinery and Equipment. The Hydraulic Association, which comprises fourteen of the leading British makers of hydraulic equipment, have sent us a copy of a booklet which sets out in a tabular form the various products as manufactured by the member concerns. A wide range of products in the hydraulic-equipment field is covered and approximately 500 items are listed. The booklet may be obtained from the offices of the Association at 94/98 Petty France, London, S.W.1.

Alternating-Current Motors. A booklet issued by Lancashire Dynamo and Crypto Ltd., St. Stephen's House, Victoria-embankment, London, S.W.1, contains abridged specifications, outputs, prices, dimensions and shipping information regarding slip-ring, screen-protected and fan-cooled motors for outputs from 1 to 100 h.p.

BOOKS RECEIVED

Model Analysis of Structures. By T. M. CHARLTON. *E. and F. Spon, Limited, 22 Henrietta-street, London, W.C.2.* (21*s.*)

Report on the Derailment which occurred on August 16, 1953, between Wilnecote and Kingsbury, in the London Midland Region, British Railways. Ministry of Transport and Civil Aviation, Railway Accidents. *H.M. Stationery Office, Kingsway, London, W.C.2.* (2*s.* 6*d.*)

Oil in the Middle East. Its Discovery and Development. By STEPHEN HEMSLEY LONGRIGG. Published for the Royal Institute of International Affairs by *Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4.* (25*s.*)

The Insulation of Electrical Equipment. Edited by WILLIS JACKSON. *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (42*s.*)

The Amplification and Distribution of Sound. By A. E. GREENLEES. Third edition revised. *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (35*s.*)

Newnes Engineer's Reference Book. Edited by F. J. CAMM. Sixth edition. *George Newnes, Limited, Tower House, Southampton-street, Strand, London, W.C.2.* (70*s.*)

The Electrical Engineer's Reference Book. Edited by E. MOLLOY, M. G. SAY and R. C. WALKER. Seventh edition. *George Newnes, Limited, Tower House, Southampton-street, Strand, London, W.C.2.* (70*s.*)

Modulation Theory. By HAROLD S. BLACK. *D. Van Nostrand Company, Incorporated, 250 Fourth-avenue, New York 3, N.Y., U.S.A.;* and *Macmillan and Company, Limited, St. Martin's-street, London, W.C.2.* (65*s.*)

Dynamic Stresses in Cast Iron Girder Bridges. By G. R. MITCHELL. National Building Studies Research Paper No. 19. *H.M. Stationery Office, Kingsway, London, W.C.2.* (3*s.*)

S.S. Ocean Vulcan Sea Trials. Admiralty Ship Welding Committee Report No. R.10. *H.M. Stationery Office, Kingsway, London, W.C.2.* (42*s.*)

Technical Reports of the British Electrical and Allied Industries Research Association:

The Magnetic Compass Error Caused by D.C. Single-Core Sea Cables. By F. BUSEMANN. No. B/T116. (10*s.* 6*d.*)

Heavy-Duty Contactor Contacts—Present Knowledge and Need for Research. By H. W. BAXTER. No. G/T287. (10*s.* 6*d.*)

Surge Voltage Distribution in a Continuous-Single-Disk Winding with Open-Circuited Sections as Occasioned by Various Arrangements of Voltage-Regulating Tappings. By E. L. WHITE and T. J. BROWN. No. S/T72. (18*s.*)

Indirect Lightning Surges on Overhead Distribution Lines. By R. H. GOLDE. No. S/T75. (30*s.*)

Self-Adjusting Welding Arcs. By J. C. NEEDHAM No. Z/T91. (10*s.* 6*d.*)

Offices of the Association, Thorncroft Manor, Dorking-road, Leatherhead, Surrey.

Leonardo da Vinci. A set of twelve publications issued free by the Committee in charge of the celebrations of the Fifth Centenary of Leonardo da Vinci's Birth. The publications include details of his work as Military Engineer, Geographer and Geologist, Textile Engineer and Architect. *Associazione Italiana della Stampa Tecnica, Scientifica e Periodica, Via Mercanti 2, Milan, Italy.*

Elektrische Maschinen. Volume III: Die Transformatoren. *Verlag Birkhäuser, Basel, Stuttgart, Germany.* (26 *D.M.*)

The Institution of Naval Architects (*continued from page* 556)

BOTTOM PLATE CORRUGATIONS AND WAVE RESISTANCE

DISCUSSION OF TWO PAPERS ON SHIP HULL DESIGN

The Spring Meeting of the Institution of Naval Architects was resumed on the afternoon of Thursday, April 8, when two papers were delivered, namely, "Corrugations of Bottom Shell Plating," by Mr. J. M. Murray, M.B.E., B.Sc., and "The Application of Wave Resistance Calculations to Ship Hull Design," by Mr. A. Emerson, M.Sc. The chair was again taken by Sir Charles S. Lillicrap, K.C.B. A summary of Mr. Murray's paper is given below.

CORRUGATIONS OF BOTTOM SHELL PLATING

The first examples of corrugation in bottom shell plating, said Mr. Murray, were noticed in 1946. The ships were all-welded and transversely framed, and were all of the same class, 416 ft. long by 56·8 ft. beam, and 38 ft. deep. The corrugations were distributed throughout the midship half-length and were generally upward between the floors, reaching a maximum indentation of about 1½ in. in way of the cross bunker. The ships had been subjected to considerable hogging stresses and it was estimated that the total stress in heavy weather might vary from zero to about 6 tons per square inch compression in the bottom plating. Subsequently it was found that ships which were partly welded and partly riveted were also affected, though to a less extent. Deep corrugations were usually about four frame spaces apart, with lesser corrugations between them. They did not develop at a constant rate, and might remain unchanged for as long as twelve months. Lloyd's Register undertook a detailed survey of ships under construction, having floors welded to the shell, to ascertain the extent of the deformation attributable to the welding, which was found to have a maximum value of about 0·3 in; and the British Shipbuilding Research Association carried out experiments, on full-sized models, to determine the difference between the strength in compression of riveted and of welded construction.

The conclusions reached were that transversely-framed ships of all-welded construction were inherently liable to corrugation, generally associated with corrugation of the tank-top plating also; that the only structural means of eliminating it in welded ships was the introduction of longitudinal framing in the bottom; and that, once initial deflection had been sustained, the deflections would increase gradually over a period of years so that eventually the efficiency of the hull girder would be reduced and the stresses increased to an unacceptable extent unless the ship was stiffened by longitudinal panel-breakers. The theoretical studies gave results which were reasonably in accordance with the experimental work, but it was apparent that the bottom structure of a ship was too complex to be amenable to precise theoretical treatment.

DISCUSSION

The chairman, in declaring the paper open for discussion, observed with regard to the author's conclusion that "The only structural means of eliminating this species of failure in welded ships is the introduction of longitudinal framing in the bottom," that the Royal Corps of Naval Constructors had realised this lesson perhaps 30 years ago.

Mr. J. Hodgson considered that the paper was of great practical importance in relation to both the general and the structural design of cargo ships. It must be admitted that thermal contraction in welds was inevitable and that some initial deflection in welded panels of plating between stiffening members was therefore unavoidable; if those members were rigid, the deflections were likely to be significant. It was not suspected originally that the small deflections in the bottoms of welded ships would seriously impair the structural efficiency of the plating acting as the bottom flange of the ship girder. Experience over several years had shown, however, that the buckling strength of bottom plating so deflected was insufficient to withstand the compressive stresses experienced in service. That experience has been overwhelmingly conclusive, from the point of view of Lloyd's Register. Within the limits of experimental accuracy and the assumptions which must be made in Mr. Murray's theoretical analysis, he thought that the paper did explain the mechanism and the chief characteristics of the observed service behaviour. The examples given well illustrated the observed facts, how the deflections grew after a number of years of service and eventually produced very serious deflections between the floors and the bottom of a welded ship. Experience confirmed that a riveted panel might be expected to remain completely stable and efficient up to a higher compressive stress than in the case of the initially deflected welded panel. That was an important point; but, as the author pointed out, the modern cargo ship of all-riveted construction did experience compressive stresses in the bottom high enough to buckle the plating. The factor of service stress was, therefore, of primary importance.

In his paper on "Ship Structures," read before the Institution in 1951, R. B. Shepheard dealt with the increase in hogging bending-moments due to changes in design from the old poop, bridge and forecastle coal-burning type to the modern shelter-deck oil-burner of higher speed. He pointed out that whereas, in the old type of ship, the sagging moment in the unvarying ballast condition was the most critical, in the modern ship the hogging moments in the variable loaded condition were the governing consideration. In modern advanced designs with high speeds, the hogging stresses in the homogeneously loaded condition could be excessive. Long machinery space, fine form, and often the provision of cargo space at the ends in long forecastles or poops tended considerably to increase the hogging moments and stresses on the ships; and it had become necessary, in designing modern cargo liners, to give careful consideration to the disposition of cargo spaces and the fuel and water carrying spaces in order to minimise hogging moments and stresses in the loaded condition, and, incidentally, to avoid the necessity of an increase in the scantlings of the ships. Moreover, if the design stress in the homogeneously loaded condition was high, greater care was necessary in loading ships when carrying heavy cargoes, to avoid undue weight being loaded in the foremost and aftermost spaces; and the captain had less latitude of safety in distributing heavy material. Appendix I of the paper, which gave a number of voyages for a shelter-deck ship, illustrated that very clearly by the comparative stress figures. They showed that, with a cargo of phosphates, it was possible to vary the probable compressive stress in the bottom from 2·5 to 6·5 tons per square inch by different distributions of cargo.

With regard to structural design, he would emphasise what the chairman had said; it must be quite clear, so far as the welded-ship bottom was concerned, that, to eliminate the type of defect investigated in the paper, the only solution was to fit longitudinal framing in the bottom. To fit subsidiary longitudinal stiffeners as panel breakers in conjunction with the transverse system was structurally less efficient and probably not so economical as the straightforward longitudinal framing for new ships. In many cargo ships of modern design, whether welded or riveted, longitudinal framing was necessary to give a more rational and economical disposition of the material to meet the higher service stresses; and that applied both to the bottom and the deck.

Mr. H. J. Adams said that the author had produced a classic paper, giving full-size and experimental results and theoretical investigation; and there was general agreement between the three. In a subject of such complexity, general agreement was all that could be expected from the theory, but the author's assumptions of end fixity for the panels had proved fairly accurate. It was stated in the paper that the transverse-frame ship of all-welded construction was inherently liable to corrugations of the outer plating; that, because of the welding of the floors, the plating was initially dished to some extent; and that increase of the corrugation occurred later, due to sea stresses. He believed that, even if a method were devised to weld the bottom without any dishing, there would still be corrugations with that type of construction; it was not the dishing which was the important factor, but the fact that the bottom was all-welded. There were many cases of ships which, when on the stocks, appeared to be perfectly fair, but when docked, a few months afterwards, before trial, had been found to have considerable corrugations. It seemed to him that, if there was no unfairness due to the welding of the floors, sufficient unfairness would arise in some other way to cause the corrugation of that type of bottom in later years.

If corrugations were isolated and not deep, they were probably not of great importance, but they required to be watched to see that they did not develop a pattern. The dangerous pattern, obviously, was in line across the bottom. The author mentioned that, at the end of the engine room, often the corrugations were excessive. That also occurred in line with the end of the long deckhouse on occasion, particularly if there was a hatch just forward of it. A particularly bad case could occur in small vessels where the end of the poop and the end of the engine room coincided, particularly if the engine room had a double bottom and the remainder of the ship had a single bottom. He believed that to be only partly a normal corrugation; some of it, he thought, was due to the break in the strength of the ship at those points, and that corrugation and discontinuity usually resulted in a line of corrugations across the ship, which showed, by cracking of the paint, signs of working. In excessive cases, the plating often became very thin; he had actually seen it holed, due presumably to its working, in addition to the normal corrugation of the plating.

If anyone had any doubt whether it was necessary to stiffen a particular ship which had corrugated, he might remember that the corrugations were only seen when the ship was in dock – in other words, when the stresses were relatively low. Possibly, if the corrugations could be viewed when the ship was on the crest of a hogging wave, they would be alarming.

The valuable curves given in the paper showed that, if the deflection was 0·15 at a nominal stress of 5 tons per square inch, the efficiency of the panel was reduced by only about 4 per cent., which meant that the efficiency of the ship at the deck was practically unchanged, and at the bottom it was reduced by about 4 per cent. If, however, the deflection was 0·2, the efficiency of the panel was reduced to about 55 per cent., the strength of the ship at the deck was reduced to about 96 per cent., and at the bottom it was about 80 per cent. Yet that was a very small deflection; no doubt, if it were increased to the values that were really obtained in ships, the strength would quickly become seriously reduced. With regard to the experimental work: it was always easy to be wise after the event, but apparently it would have been better to have five panels instead of three, to get a better idea of the end effect. He noted that, in Section II of the paper, the author assumed that, for small initial

deflections of the order of $p = 0{\cdot}1$ or $0{\cdot}2$, the constraint was 80 per cent.; but in Section IV, for $p = 0{\cdot}2$, he assumed a constraint of 50 per cent.

Mr. L. G. Stevens said that the crucial point in the theoretical considerations of the paper appeared to be the determination of the degree of constraint at the edges of the panels. The method used, however, did not seem to be sufficiently independent of the result it was attempted to explain; he wondered whether it was not a description of what happened rather than an explanation of why it happened. It appeared, from Section IV, that the author used the altered edge restraint on unloading, following compressive stressing, to explain why a second application of the same compressive stress would cause greater deflection than it did on the previous application. That was difficult to understand, unless there had been some inelastic behaviour in the unloading and restraining cycle, such as might occur if the tension following the compression cycle were of sufficient magnitude to increase the permanent set. It seemed doubtful whether tension of sufficient magnitude would often be encountered, though effects might be accentuated by a re-distribution of stress between adjacent panels due to the deflection of the floors. Had the author taken either of those possibilities into account ? Unless something of that kind took place, the residual stresses on unloading would be such as to ensure that, on re-loading (elastically) to the previous value, exactly the same deflection would occur, and further yielding would occur only if the load were increased.

The author stated that " The pattern of corrugations, in its initial stages, alters while the ship is in service; later, when deeper corrugations develop, it tends to become more or less fixed, though there are on occasions instances of instability when the corrugations become large." He also stated, however, that " The corrugations do not develop at a constant rate; they may grow to quite an important size, and then remain unchanged for as long as twelve months." Might the growth of the corrugations after a period of relative constancy be associated with some particularly heavy weather conditions in which tension in the stress cycle caused further yield ? Had any specimen, except the specimen that was welded and stiffened, been subjected to repeated applications of stress?

Mr. J. B. Caldwell, commenting on the author's analysis of the effect of corrugations on the longitudinal strength of a ship's hull, pointed out that, in a welded ship with an initial deflection of $0{\cdot}1$ of the thickness of the plate, when the nominal stress in the ship's bottom was 6 tons per square inch the maximum combined stress on the plating was 20 tons per square inch. It was then assumed that the yield stress had been exceeded at some point in the plate and that the subsequent permanent deflection was of the order of $0{\cdot}2$ of the plate thickness. If the ship was again stressed to 6 tons per square inch in the bottom, the extrapolation of the curve (*b*) in Fig. 15 of the paper gave a stress of the order of 40 tons per square inch. That, he thought, was stretching the argument too far, but it illustrated some points he wished to bring out. The theory tended to overlook an aspect of the bending of a ship's bottom which might have some influence on the formation of corrugations. Considering two floors which were initially a fixed distance apart: when the ship sagged, the two floors would approach each other by a given amount. When the ship was unloaded, they would separate to their original distance; on reloading, the stress brought the two floors together again by the same amount as before. Whatever had happened to the deflected plating during loading and unloading and re-loading, it was a little difficult to see how the situation at the end of the first loading could be very different from that at the end of the second loading; so the stresses to be expected from the author's curve (*b*) seemed to over-estimate the situation rather badly. The root of the matter appeared to be that, on unloading, if the deflected plating had been over-strained during the original compression cycle, when the floors returned to their original distance apart there must be some overall tension in the plating which would reduce the maximum deflection.

Professor Ir. H. E. Jaeger said that he had been working on the subject for a long time. A preliminary report was published by the Netherlands Shipbuilding Research Association in 1951. The Dutch shipbuilders had become anxious about waviness in the bottom structure, and the Research Association asked him to try to find an answer. They concluded that, on a simple theoretical basis, the stress in the bottom plating due to the initial deflection could be represented by a very simple formula. They had been working on it, and the Ships' Structures Committee gave his preliminary solution in an appendix to their report last year, provisionally accepting it as a means of explaining the phenomenon. British, Dutch, American and German naval architects were all studying the problem.

Professor A. M. Robb recalled that, during the first World War, he had suggested to some senior representatives of the then two registration societies that it would be a great help to the profession if the officials of those societies would present papers showing the troubles that occurred in ships; but a very senior official replied " My boy, we have no failures – officially ! " Open confession was good for the soul. He was happy to think that the registration society now appreciated that, and that even the tank superintendents had come to it.

Professor E. V. Telfer said that naval architects seemed to have very poor memories. The conclusion in Mr. Murray's paper that the framing should be longitudinal in the bottom was anticipated a hundred years ago in the case of the Great Eastern. The historical note was what he wanted to stress; 1954 was very late in the day to try to prevent the bottoms of ships buckling, and he would like to go to the first cause of what, in his opinion, eventually produced that buckling. It was only about 1916 that the section modulus was introduced into shipbuilding work officially by the Freeboard Commission. As the result of the work of the Commission, two types of ships became popular; one was the full-scantling ship and the other was the complete superstructure ship. Those who became modulus-minded realised that the old-fashioned ship had a very asymmetrical position of the neutral axis, and it was thought right to raise up the neutral axis and get a much better and much more efficient section. That had been done, and one of the first effects of the change in shipbuilding practice was felt by the platers in the shipyards. Before about 1920, the aristocrats of the shipyards were the platers who made the bottom plating; the deck-plating men could not make money. Suddenly, the bottoms were lightened and the decks strengthened; then the bottom platers could not make their money and the deck platers came nearer to the aristocracy. Now there was new evidence of the same effect. They had allowed the pure geometry of the section modulus to change their ideas of ship construction, and had thinned down the bottom plating of the ship much more than in the full-scantling vessel. The bottom structure had a dual duty to perform. That was what they were suffering from; and if it was known a hundred years ago, it was now about time that the fact should be more appreciated. Could Mr. Murray say whether buckling was still taking place in the full-scantling structure?

Mr. L. Woollard thoroughly endorsed the chairman's opening remark, that, for a long time, in the warship world, it had been appreciated that the advantage of longitudinal framing which was both continuous and closely spaced was that the panel stress in the plating was much smaller than with transverse framing. With the latter, the trouble in welded ships was probably due to the fact that the bottom was no longer stiffened by laps, as with riveted ships.

Captain J. P. Thomson said that, in 40 years' experience of large tankers constructed on the longitudinal framing system, he had never known of a failure or a case of buckling on the bottoms.

AUTHOR'S REPLY

Mr. Murray, in reply to the discussion, observed that, although the Admiralty had adopted longitudinal framing 30 years ago, Captain Thomson said that he had known about it for 40 years, and Professor Telfer mentioned that the Great Eastern was built on a system having longitudinal girders. Lloyd's Register could go back farther than that. A group of ships was built before the Great Eastern, and classed 100 A1, which had longitudinal framing throughout and many other modern features. He thanked the chairman for supporting his conclusion in that respect; it was incidental to the paper, but it was such an important truth that it could not be too strongly commended. Mr. Adams was of the opinion that the cause of the trouble was not just deformation in the bottom of the transverse-framed welded ship; it was the fact that it was welded. He thought there was something in that. Also, Mr. Adams was probably correct in saying that some corrugations seen when ships were in dry dock must become rather terrifying in service. Mr. Stevens and Mr. Caldwell made some remarks on the theoretical side. The matter was a little complex for discussion at that stage. He sympathised with their views, and hoped that he could convince them that there was something to be said for keeping off the subject *pro tem.*, especially as experiments had been put in hand to show what Mr. Stevens wanted to see, namely, the effect of repeated loadings. He hoped to publish the results in due course. Professor Telfer's historic note was interesting, but he did not think that practical shipbuilders would agree that the deck squad was more important than the shell squad, notwithstanding the increasing thickness of the decks.

With regard to the full-scantling ship versus the complete superstructure ship: the full-scantling ship was the old poop, bridge and forecastle ship; he did not know whether that was the type to which Professor Telfer referred. That type of ship was seldom built nowadays, probably in the ratio of not more than 1 in 10. He did not know of an all-welded poop, bridge and forecastle ship. Further, the inherent longitudinal stresses on poop, bridge and forecastle ships were much less than in the modern shelter-decker. He knew of a poop, bridge and forecastle ship which had been in the iron-ore trade during the war. Through force of circumstances she had not been looked at for many years, but when she came under survey and was drilled, the section modulus (a very convenient method of describing the strength) was 70 per cent. of what it was when she was built. The interesting point was that there was no record of fractures or failures or any trouble at all with the ship. The inherent longitudinal stresses were small. If he could find any support of Professor Telfer's theory, he would refer to it in his written reply. In reply to Mr. Woollard, he did think that laps had something to do with it but not all.

The chairman, in thanking Mr. Murray for his paper, added that he was quite prepared to extend his claim of 30 years' priority to 50. He then called on Mr. A. Emerson to present his paper on " The Application of Wave Resistance Calculations to Ship Hull Design," a summary of which is given below.

WAVE RESISTANCE AND SHIP HULL DESIGN

The method of obtaining a hull form which would satisfy given design conditions and have the least possible resistance at a stated speed, said Mr. Emerson, was at present empirical. The wave resistance of a model was usually estimated by subtracting the skin frictional resistance from the total measured resistance; but that division was inaccurate and might lead to appreciable errors in the so-called " measured " wave resistance. At low speeds it was not possible to compare the measured and calculated values, and at high speeds, because of the change in trim and the high waves, the portion of the hull below the water surface, which caused the wave-making, was very different from the underwater shape at

rest, for which the calculation was usually made. Between those two extreme conditions there was the vital medium to fast speed-range, from $\frac{V}{\sqrt{L}} = 0{\cdot}9$ to $1{\cdot}2$, for which, he suggested, it should be possible to obtain agreement in the shape of resistance curves without considering the additional complications outside that range. Dr. R. Guilloton had demonstrated (*Trans. I.N.A.*, vol. 94, page 343, 1952) that the wave resistance calculated from the measured wave profile agreed reasonably with the " measured " resistance; and W. C. S. Wigley (*Trans. I.E.S.S.*, 1938) had devised an approximate correction for the effects of viscosity which could be adapted to the comparison of measured and calculated wave resistance. This involved the use of a correction factor which appeared to decrease from unity with increase in beam and in fullness of endings; in other words, with the variation of the angle of the hull to the centre-line plane. The implication was that, if the angle of the hull to the centre-line plane was not small, the initial wave might have the calculated height, but the second crest was less than was calculated, with a corresponding reduction in the interference. There was some evidence to suggest that even the first hollow was appreciably shallower than the calculated value.

The application of calculated results could not be extended indefinitely to wider beams and fuller endings; as the angles increased, with full afterbodies, eddy-making or separation would alter the wave-making contribution of the hull abaft the position of separation. By using an extension of Sir Thomas Havelock's method of computing wave resistance (*Trans. N.E.C. Inst.*, 1943) it was possible to show by calculation which parts of the hull were making a major contribution to the resistance and what effect possible alterations would have. Such an analysis would establish corrections for breadth and would take into account variations in depth; existing resistance data would then have a more general application, without restricting comparisons to ships of the same proportions. If it proved not practicable to obtain the desired result by correcting the mathematical treatment, the correction factors could be obtained from a study of wave profiles on selected models, or, for design purposes, might be derived from the mass of model data in existence. It was the author's conviction, however, that the present reliance on model testing alone not only made for slow progress, but was inherently dangerous.

DISCUSSION

Professor Sir Thomas H. Havelock, F.R.S., who opened the discussion, said that Mr. Emerson had made a useful attempt to make up for the deficiencies of wave theory, so that it may be used practically in ship design. He agreed that, for that purpose, it was necessary to supplement the usual theory by introducing empirical correction factors. There were three conditions for the use of such factors, namely, that the basic theory should, if possible, be good enough for the necessary corrections to be relatively small; the definition and application of the factors should be based on reasonable assumptions ; and the corrected results should give the right answer. Mr. Emerson used two factors, α and β, introduced into the resistance, in the section of the paper headed " Empirical Corrections." The β factor was clearly associated with boundary-layer effect on the stern wave system; it might be regarded as a reduction in the amplitude of the stern waves. The value $0{\cdot}95$ taken for β seemed rather high, and perhaps Mr. Emerson would expand his reasons for taking that value. The α factor was more difficult. If the boundary-layer effect had been properly accounted for by the β factor, there was not much left for further viscous effects; the mere damping of the waves by ordinary viscosity must be quite small. He agreed with Mr. Emerson in regarding the α factor as a more general correction, probably associated with the effect of finite beam. Possibly it might be called a shielding or screening factor; the body of the ship screened the stern from the full effect of the bow waves. The introduction of that factor into the resistance was not so obvious as for the β factor. Some increase of amplitude might be expected at the bow, as well as a reduction of the bow waves at the stern. However, the interference effect was probably the most important part. The general idea of the function of the α factor, as shown in the paper, was borne out by its diminishing value with increasing beam, or again by its small value for a model with the full end leading. He would also expect α to be small at low speeds, when the wave length was small compared with the model length. Mr. Emerson remarked, in his discussion of correction factors, that, for lower speeds, α could be reduced, but it would no longer have a physical meaning. Professor Havelock did not follow that argument; had the author obtained any values at low speeds? From a theoretical point of view, the paper was valuable as giving an estimate of the relative importance of the two corrections.

Mr. H. G. Hogben considered that, at present, the correlation of measured and calculated results was the most important, but the least satisfactory, aspect of wave-making research, and it was reassuring that Mr. Emerson seemed to bring theory and practice so closely into line. He had regarded the α factor as being related physically to the viscous damping of the bow wave as it moved aft. It seemed, however, that that was not so; as Mr. Emerson pointed out, a difficulty arose at lower speed, where there was a large number of effects in the length of the ship. The trouble seemed to be that the α factor did not envisage a gradual dying out of the amplitude of the wave, but a sudden change at amidship to more amplitude. Could some law be developed in introducing the calculation? To do so would complicate the analysis, but it might be of interest. It might be related, perhaps, to Reynolds number. He felt confident that the author's ideas would bear fruit and that the gap between theory and practice would be narrowed.

Professor J. Weinblum agreed with the author in his concluding remark that the present reliance on model testing alone not only made for slow progress, but was inherently dangerous, and with his comments on the use of the theoretical approach as a tool and a check; but he thought that the standard series of curves presented an indispensable working hypothesis when discussing resistance properties and developing ideas as to the direction in which changes in the ship form should be made in order to improve its qualities. The use of Mr. Wigley's semi-empirical formula (which itself represented the development of an idea due to Sir Thomas Havelock) by the author appeared to be successful. Finally, he would mention the Taylor Model Basin work which made possible an almost immediate evaluation of Michell's integral for simple hull form.

Professor L. C. Burrill thought that many naval architects had feared to tackle the mathematical calculation of ship wave resistance because of its formidable nature, and possibly had not realised that the curves published previously concealed to some extent the marked discrepancies existing between the calculated values and those obtained from models. He was entirely in favour of the pursuit of mathematical excursions, and would not ask the mathematicians necessarily to provide proper and accurate solutions. At the same time, if they were to use the mathematical approach for testing or checking practical results, they must be satisfied that, whatever the means adopted, they did get somewhere near the right answer. He supported the approach whereby the author introduced what was clearly an arbitrary correction factor. It should produce from a mathematical calculation something like a physical result.

Mr. B. J. L. Hall observed that previous speakers had mentioned that, apparently, the calculated values for wave resistance did not vary as the square of the beam. It should be realised that the variation of resistance with beam was not always so simple; in considering fairly full forms, that might be very important. He would like Mr. Emerson to amplify his assumed 5 per cent. virtual lengthening of the form, in considering the effect of the boundary layer. Obviously, the effect of viscosity must be to prevent the streamlines from fairing themselves as they would if there were no viscosity, and that would result in the lengthening of the form. Also, it must result in filling out the end of the form.

Mr. W. C. S. Wigley thought that Mr. Emerson had been more scrupulous than he himself had been. In the equation quoted in the section headed " Empirical Corrections," as there were two arbitrary constants, he (Mr. Wigley) had assumed that they were to be used singly, because of the complication involved if both were used. Mr. Emerson had gone a stage further, and it was an advance when they noted how nearly they could get to the right answer with that change. There were several theoretical objections to the procedure, but the answer seemed to come out all right.

Mr. J. R. Shearer said that it was interesting that, in the field of aerodynamics, the application of the theoretical approach to the design of aerofoils had given drags substantially lower than were ever obtained by empirical means, and he felt that the same stage might be reached eventually in the field of ship resistance. He felt that a full form had a tendency to concentrate areas of wave-making, that the lengths where the waves were generated were rather concentrated. Perhaps the influence of viscosity was less.

Professor E. V. Telfer noted that, in Fig. 2, the values given were of wave-making resistance, corrected for beam. That was confusing, because the model which had the highest resistance had the least beam; in fact, the wave-making resistances varied inversely as the beam, and certainly not as the square of the beam, as Mr. Hall had pointed out. For some reason, the relation was completely reversed. That might be due to the fact that the whole of the correlation work involved in the paper depended on the particular frictional resistance value which the author had been forced to adopt. That type of effect could be obtained with very slim models; if the specific frictional resistance did increase as the equivalent length/depth ratio of the model, additional skin friction appeared in the slimmer model. That seemed to be the explanation of Figs. 5 and 6, where Mr. Emerson reviewed the Taylor comparison. There it was based on quite a high specific resistance. The original Taylor specific resistance had a value of about $2{\cdot}83$. If the possible range of specific resistance due to the range of length/depth ratio of the model were calculated, it varied from about $2{\cdot}89$ down to $2{\cdot}7$ for the infinite-area form. The effect of that could be seen in the diagrams by the prediction of the very slim models being too low and the prediction of the very full models being too high, which appeared to be completely in harmony with the variable specific resistance being a function of the length/depth ratio of the model.

AUTHOR'S REPLY

Mr. Emerson, in his reply to the discussion, said that various speakers had referred to the nature and definition of the α factor. As he saw it, if α were minimised, there would be no more theory in the theoretical approach than at present. It was essential to have a large amount of model data and to spend a long time trying all the variations. If he had to design a model in a range for which he had not close model data, he would do the calculations for the model data that he did have and apply the corrections. Sir Thomas Havelock's suggestion of the screening factor was very illuminating, and the point he mentioned about α at low speeds followed from the discussion in the paper. As for the time required to make these calculations, once the calculations had been reduced to a standard concentration, the calculating machine could be used and the work did not take long. The more knowledge that ship designers had of the background of wave profiles and resistance, the better would be the results achieved.

To be continued.

METALS AND MARINE ENGINEERING*

By Dr. S. F. Dorey, C.B.E., F.R.S.

Before considering applications of non-ferrous metals in marine engineering, it might perhaps be as well for me to give a brief outline of the outstanding developments made in this field since the foundation of the Institute in 1908.

During this time, steam conditions have increased, on an average, from pressures and temperatures of 240 lb. per sq. in. and 400 deg. F. to 625 lb. per sq. in. and 950 deg. F., respectively. Associated with this progress have been the change over from coal to oil fuel and the displacement of the steam engine by the steam turbine for high-powered propulsion purposes.

The oil engine, which has almost displaced the steam reciprocating engine as a prime mover, was at a very early stage of development in 1908, 250 h.p. being the maximum power available, for marine purposes, from engines constructed in this country. The advance of this engine has been remarkable, however, power outputs per cylinder increasing from 80 h.p. to an existing value of over 1,500 h.p., and exceeding 2,000 h.p. for engines at present under construction.

CORROSION

At the beginning of this century the corrosion problems associated with marine condensers were of a sufficiently serious character for this Institute to found, in 1910, a Corrosion Committee, the specific purpose of which was to investigate the causes leading to the failures encountered. The series of eight reports subsequently published, and the guidance they afforded, were valuable contributions towards the solution of a most serious problem. The marine engineer has derived great benefit as a result of these investigations and their continuation by the British Non-Ferrous Metals Research Association since 1930.

Existing normal service conditions of marine condensers are well within the estimated limits of the improved alloys. However, operation involving polluted cooling waters still presents an important problem. Cupro-nickels have been proposed as the most suitable tube materials for this type of service, as both 70 : 30 and aluminium brasses have proved unreliable. It must be admitted, however, that this proposal does not offer an entirely satisfactory solution, and it is desirable that investigations of deterioration in polluted waters should be continued.

Associated with this problem are those involving severe pitting of these alloys due to marine growths. Bio-fouling tends to be more severe on alloys having enhanced corrosion-resistance. In addition to causing pitting by its own action, the growth tends to trap decaying debris, thereby increasing the attack on the metal surface. Adequate water velocities and careful maintenance assist in reducing these forms of deterioration, but as both polluted-water and bio-fouling effects are allied, investigations should serve a dual purpose.

A most serious corrosion problem exists in oil-tankers, which carry alternately oil cargo and sea-water ballast in the same tanks. Flat surfaces and other regions which do not drain efficiently undergo rapid corrosion. The combined influence of the oil and the sea water promotes this extreme deterioration, the high oxygen contents of the oils being mainly responsible, although the sulphur content has also been suggested as an additional contributory factor. Steaming out of the tanks aggravates these conditions by loosening adhering scale and increasing the chlorine-ion concentration at the higher temperatures involved. Although cathodic protection, involving the use of active magnesium or other type of anode, has been applied in limited instances, controversy exists as to the economic and practical advantages obtained.

Aluminium alloys are claimed to have a high resistance to corrosion under these conditions and might offer alternative means of reducing deterioration either as spray coatings, linings, or complete tank units. So far these alloys have not been tried, but future development may involve their use.

CAVITATION EROSION

One of the most severe forms of metallic-surface deterioration is associated with damage sustained by cavitation erosion. Under the suction conditions of dynamic fluid flow, the surfaces of propellers, impellers, and similar hydraulic-machinery components may suffer this form of erosion. The collapse of cavities formed on these surfaces is considered to release quantities of energy in the form of localised forces, similar in nature to water hammer. The magnitude of these forces may be sufficient to bend propeller blades, but their confined character more commonly induces highly localised stresses in the metal, producing surface rupture and severe distortion of the crystal structure. Damaged surfaces tend to increase local turbulence, enhancing cavitation tendencies and extending the depth and area of the eroded zone. The mechanism of failure is not fully understood, and controversy exists as to the part played by corrosion.

Marine propellers undergo this form of damage to varying extents, depending on the design, the conditions of operation and the material of which they are made. Cast iron and cast steel are prone to have local regions of porosity which are easily eroded and give rise to a deeply pitted form of attack. Bronzes, which are of a more resistant nature, exhibit eroded regions having the appearance of areas that have been subjected to intense local sand-blasting. Despite their more resistant nature, however, bronze propellers have been known to decrease in weight during service by as much as 10 per cent., attributable to overall corrosion and erosion losses. Such losses not only impair the propeller's efficiency, but also reduce its inertia. In consequence, the one-node mode of torsional vibration of the machinery's dynamic system will be raised, and critical vibrations may be placed out of barred speed ranges or brought in close proximity to service or operational speeds.

Improved propeller designs based on extensive hydrodynamic studies are expected to reduce cavitation conditions, but the higher powers transmitted and the turbulent flow imparted by the stern of the ship will limit the benefits likely to be obtained. The application of alloys having the maximum resistance to this form of cavitation erosion has therefore been considered. In order that the relative merits of the available alloys might be ascertained, experimental techniques simulating extreme cavitation conditions on the surfaces of suitable specimens have been adopted. Erosion-resistances are based on weight losses in standard exposure times and, while some degree of variation of results is inevitable, close guidance is given to the relative resistance of the alloys involved. A reasonable assessment of the erosion-resistance of an alloy is given by the product of the surface Brinell hardness number and the corrosion-fatigue resistance expressed in tons per sq. in. for 50 million cycles of reverse bending. The more highly resistant alloys have values in excess of 800, and in descending order of merit they include austenitic stainless steels, aluminium bronzes (with or without nickel additions), low-nickel stainless steels, silicon Monel, Monel metal, high-tensile bronze, and Turbadium bronze. Below 800, the normal manganese bronzes, silicon bronzes, phosphor bronzes, gunmetals, cast irons, and aluminium alloys are placed. This does not imply that the manganese bronzes which have given such fine service have poor resistance, but they are used purely as a basis of comparison.

The latest materials used for large marine propellers are copper-aluminium alloys with nickel and iron additions, resembling that specified in B.S.1400 A.B.2, and the more recent copper alloy with high aluminium and manganese content. Castings having maximum weights of 25 and 35 tons have been made in these alloys, respectively, and even larger castings are under consideration.

FATIGUE

The corrosion-fatigue strengths of many alloys have been determined experimentally for cycles of stress in excess of 50 million, and they provide the engineer with useful design data. However, with the exception of steels, there is a lack of information relating to the influence on the corrosion-fatigue strength of mean stress, stress concentration, and combined-stress conditions. At elevated temperatures the influence of mean stress in relation to fatigue is of marked importance, owing to the deformation due to creep.

The magnitude of vibratory stresses, occurring when natural frequencies of components are excited by external influences, is dependent on the degree of damping available. While the significance of the damping capacity of materials has not yet been fully assessed, in instances where accurate determinations have been made low values have been recorded for many metals and alloys. Internal damping cannot, therefore, be relied on to limit alternating stresses to values below the fatigue strength. This does not necessarily imply that the inherent damping properties of metals are insignificant, for, in similar applications, a metal of superior damping characteristics might give longer service life.

USE OF METALS AT ELEVATED TEMPERATURES

The advent of the gas turbine has focused attention on the requirements of alloys for service at elevated temperatures. The development of both ferrous and non-ferrous metal alloys to meet these needs has been indeed remarkable. As operating temperatures even higher than those at present employed would be desirable, the search for superior materials continues. In this country, with the exception of the well-established Nimonic series of alloys, ferritic and austenitic steels have so far proved most suitable for these purposes. In the United States similar conditions prevail, although more extensive use has been made of cobalt-base alloys and alloys containing high proportions of this metal. Both heat- and creep-resisting steels contain high total contents of nickel, chromium, cobalt, molybdenum, titanium, niobium, tungsten and manganese, thus demonstrating the important significance of non-ferrous metals in these applications. Indeed, the total content of these metals frequently exceeds 45 per cent., and for heat-resisting purposes the higher the temperature, the greater the amount of non-ferrous metals present.

With extensive research programmes in progress throughout the world, embracing both metallic and non-metallic materials, in an endeavour to raise operating temperatures as high as possible, the engineer can only await further developments made by the metallurgist.

Metal-to-metal contact is not uncommon at elevated temperatures, and galling has frequently been encountered at steam-valve faces and guides. All steels are susceptible to this form of surface rupture, and the use of Stellite surface deposits has proved the most feasible method of overcoming these difficulties. Silicon Monel metal has good anti-seizing properties at these temperatures, but the low ductility and high hardness of the cast 3·75 per cent. silicon alloys can lead to thermal cracking with temperature gradients.

For steam-turbine blading the ferrous alloys have almost completely replaced non-ferrous metal alloys in new construction. Stainless iron

* Presidential address delivered before the Institute of Metals at the Annual General Meeting, on Tuesday, April 27, 1954. Abridged.

and nickel-chromium ferritic and austenitic steels are the most commonly employed, replacing existing copper and nickel-copper alloys. Non-ferrous materials are widely used for gland purposes, and the most suitable alloys at various operating temperatures are said to be: brass up to 850 deg. F., S Monel (3·5 per cent. silicon) below 1,300 deg. F., and Nimonic 75 for higher temperatures.

APPLICATIONS OF LIGHT ALLOYS

The advantages of lightweight construction, employing aluminium alloys of suitably high specific strength and good corrosion resistance, are not so marked in shipbuilding as in other transport industries. In addition, the extensive experience obtained in steel construction and the equipment of yards to handle steel fabrication have militated against the use of light alloys when the latter are not readily adaptable to similar processes. The extension of light alloys to ship construction has, therefore, been based more on long-term policy, and extension of their application is increasing with design and practical experience.

Scantlings of aluminium structures have been based on somewhat greater values than those given by the strength ratios of the equivalent in steel. Weight saving, therefore, amounts to approximately 50 per cent. of a normal steel structure.

For structural purposes aluminium alloys with up to 5½ per cent. magnesium are considered most suitable. With this maximum magnesium content and small additions of manganese and chromium, the tendency for precipitation of the β phase has been obviated, and so has the stress-corrosion associated with the presence of this phase. Aluminium-4 per cent. magnesium alloys (N 5/6) are used for plate manufacture, as they are more suitable for hot working than those of higher magnesium content. The mechanical properties are generally good and meet the maximum stress requirements of 17 tons per square inch with comparative ease. Further, their good welding characteristics render alloys of this composition superior to those of the heat-treatable type of alloy. There is, therefore, a tendency for this material to be more widely used, and in America alloys of similar composition may in future be employed in preference to the existing 61S-T6 alloy.

The high-strength, heat-treated Duralumin and aluminium-magnesium-zinc types of alloy are not employed in marine construction owing to their inferior corrosion-resistance. In the clad condition these alloys are not economic propositions, although they have been employed in some German naval vessels.

Many small craft have been constructed entirely of light alloys, using normal and stressed-skin techniques. They provide means of gaining general experience of fabrication methods, as illustrated by the recent manufacture of a 72-ft. yacht of light-alloy welded construction. For the aluminium alloys to be extensively used in ship construction, efficient welding techniques must be developed. The self-adjusting inert-arc method, as used in the fabrication of this yacht, at present provides the most suitable method of fusion welding. However, as yet, this method is severely limited for general shipyard use by the degree of penetration obtained, the need to maintain a clean and corrosion-free filler wire, and the difficulties of maintaining an inert atmosphere during open-air welding. The high degree of reliability attained in the fusion welding of steels has, therefore, placed aluminium alloys at present in a less favourable position.

Ease of handling gives the light alloys great advantages for hatch covers, crankcase doors, and similar applications. In the engine room, however, apart from these uses and piston castings, light alloys are not extensively employed, as the savings in weight are not sufficiently vital. Where these alloys are employed for crankcase, sump, and cylinder castings, the engines concerned are generally used for other land purposes where these features are advantageous. Some engine builders have even considered offering cast-iron as an alternative for marine purposes. In consequence, the cast-aluminium alloys containing silicon and magnesium find only limited scope in the machinery of merchant ships.

The ultimate tensile strength of aluminium alloys used in ship construction is still relatively low, 20 tons per square inch being an almost limiting value for normal plates and sections. It must, therefore, be appreciated that the development of alloys having superior strength while retaining the other desirable properties of existing alloys, remains an important consideration.

The remarkable resistance of titanium, in the high-purity form or with small alloy additions, to severe attack by both hot and cold sea water, has aroused the interest of the marine engineer. Although this metal has not so far been used for marine purposes, the mechanical properties and corrosion-resistance are of such a high order as to render it very suitable for many applications in this industry.

BEARING METALS

In practice, two main types of plain bearings are used: thin- and thick-shelled. For heavy-engineering purposes, where heavy loads, low speeds, and flexibility occur, thick-shelled bearings are employed. Moreover, in internal-combustion engine practice, when line boring is preferred, thick-shell practice is obviously involved. The shell thicknesses vary from 8 to 12 mm. at a journal diameter of 600 mm. to 2 to 4 mm. for small-diameter shafts.

In practice, failures of thick-shelled bearings are divided evenly between two types: (*a*) wiping and running of the metals, and (*b*) cracking or breaking up of the surface. A high percentage of failures of type (*a*) were due to oil starvation arising from neglect. Cracking of bearing metals by fatigue is exceedingly common, and may be associated with high oil temperature or simply with the inability of the metal to resist the loading conditions.

Alternative bearing metals having increased strength, while retaining the other qualities of the high-tin Babbitt metals, have not yet been produced, and engineers must, therefore, contend with the failures as best they can. Whether the aluminium-20 per cent. tin alloys or the 30: 30: 40 copper-silver-lead alloy, exhibiting higher fatigue properties, will prove superior to those now used in thick-shell applications has yet to be demonstrated.

FUSION JOINTING AND DEPOSITION OF METALS

In marine engineering the efficient welding of thick sections is essential, and many processes perfected for thin-gauge material have very restricted application. The degree of perfection attained in jointing steels by electric arc-welding processes has not been approached by any method applied to non-ferrous metals. Less extensive usage may be partly responsible for this fact, although greater complications of oxidisation, melting points, thermal conductivity, and solidification characteristics have presented more formidable difficulties in these applications. In all instances, the degree of success obtained in fusion welding is greatly dependent on suitable preparation, fluxing, the development of efficient techniques, the operator's skill, and pre- and post-heating requirements.

The cadmium plating of steel in contact with aluminium has been proposed in construction involving these two metals. The favourable electrode potential of cadmium could be utilised on the surfaces of steel bolts and similar items in contact with aluminium. Cadmium may, therefore, be used in this form to an increasing extent, engine builders in other industries having already proved its merits in reducing these dissimilar-metal problems.

Non-ferrous metals are readily used in all these deposition processes, but fusion-welding methods have not yet attained the desired efficiency required for marine purposes, particularly in regard to aluminium alloys, some alloys with aluminium contents, and many high-temperature materials. The use of these materials is being influenced by this feature and can be increased only by the introduction and development of more efficient and reliable welding methods.

THE DOMAIN STRUCTURE OF FERROMAGNETIC METALS*

By Professor L. F. Bates, PH.D., D.SC., F.R.S.

I want to deal with a number of concepts and experiments which are of great importance to all who are concerned with the study of ferromagnetism and which should, therefore, be of general interest to metallurgists. I begin with the concept originally advanced by Pierre Weiss to explain the fact that we may take a piece of unmagnetised iron and, by the application of a field of a few oersteds, magnetise it to technical saturation. The examination of single crystals of ferromagnetic substances shows that such crystals exhibit directions of easy and of difficult magnetisation, and we say that such crystals are magnetically anisotropic. We have no difficulty in accepting the Weiss concept that an unmagnetised crystal is made up of small regions or domains, each magnetised to a degree of magnetic saturation which is determined by its temperature and state of strain, etc., along an easy direction of magnetisation.

If, however, each domain in an unmagnetised iron crystal is actually magnetised parallel to one of the cube edges of the crystal, why does not the whole specimen automatically form one single large domain? This was the question answered by L. Landau and E. Lifshitz in 1935, following their examination of the magneto-static energy associated with the free poles on the ends or sides of such a completely magnetised specimen. They showed by means of a series of simple diagrams that the magnetostatic energy could be greatly reduced by replacing the single large domain block, magnetised in one direction only, by a series of smaller domain blocks magnetised consecutively in antiparallel directions, so that the positive and negative magnetisations, or free poles, at the ends of the many smaller domains more or less neutralised one another. And, with a little thought, small triangular subsidiary domains, termed closure domains, could be devised to ensure that practically no flux at all escaped from the specimen.

Adjacent domains are, of course, magnetised in opposite directions, and these 180 deg. domains, as we will now call them, have to be separated by boundaries or regions of gradual transition from one direction of magnetisation to the other. We therefore speak of a 180 deg. boundary or wall, in which the magnetic-spin vectors along a line of atoms gradually change from one direction to the antiparallel one as we pass though the wall. As the exchange coupling energy between two neighbouring electron spins depends on the square of the angle between their spin vectors, it follows that there is a tendency for the wall to be as wide or as thick as possible. Indeed, in some nickel-iron alloys of low anisotropy, these

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boundaries, or Bloch walls as we often call them, are really comparatively wide, so that experiments of the type which would easily reveal their presence in the case of pure iron crystals fail with crystals of these alloys.

But a 180 deg. wall cannot have an unrestricted thickness, for only a very little of the material inside the wall can be magnetised along an easy direction; consequently exchange energy decreases with increase in wall thickness and magnetic anisotropy energy increases therewith. The result is that the overall wall thickness is determined by the two conflicting energy claims, and an approximate expression for the thickness in terms of the two energies may easily be derived. In the case of iron, a 180 deg. wall is about 10^{-5} cm. or 300 atoms thick.

If a circular disc is removed from one of the sides of a hexagonal crystal of cobalt, an ideal specimen is obtained for the investigation of the simplest domain structure. I am fortunate in possessing such a disc, about 8·5 mm. in diameter and 0·9 mm. thick, kindly presented to me by Professor Sucksmith.

The domain structure in the unmagnetised state is easily made visible; the surface is first polished mechanically down to 0000 grade emery, and then polished electrolytically in a bath of orthophosphoric acid. During the polishing, a black powder, which is thought to be ferromagnetic, tries to form a deposit on the surface and has to be continuously swabbed away.

The case of cobalt is peculiarly simple. It possesses only two easy directions of magnetisation, perpendicular to the basal plane, whereas iron possesses six such directions parallel to the cube edges, and nickel has eight such directions parallel to the cube diagonals. Consequently, while 180 deg. domain walls are very important in iron and in nickel, boundaries between neighbouring domains magnetised along directions which are perpendicular to one another, or 90 deg. boundaries, are also very important in iron. Similarly, 70 deg. and 110 deg. boundaries are very important in nickel.

It must be emphasised that boundaries are always formed in such a way that free magnetism is reduced to a minimum.

PREPARATION OF CRYSTAL SURFACES

It is now appropriate to give more details of the preparation of crystal surfaces for this work. In the case of cobalt, it is desirable to have a true crystal plane as the specimen surface, and this is established by optical and eventually by X-ray examinations. The surface is mechanically polished down to 0000 emery, and then the Beilby layer is removed by electrolytic polishing, followed if necessary by annealing *in vacuo*. We have made several devices for ensuring excellent mechanically polished surfaces of small specimens, and a few words about electrolytic polishing may not be out of place here.

Whether successful electrolytic polishing occurs because of the exceptionally high resistance of the film of liquid over the anode, or because of the peculiar denudation of the ions in such a film, is immaterial; we find that with iron and nickel the best results are obtained when both electrodes are rotated, so that the electrolyte is kept as homogeneous as possible. The single crystal forming the anode was formerly sunk in a polystyrene mould and fixed in position with polystyrene glue, electrical contact with the back of the specimen being made by impregnating the glue with graphite. More recently, a small Alnico magnet has been used as a kind of magnetic chuck without glue, and both the magnet and the specimen are polished. The latter method, of course, permits much more rapid removal of the specimens from the bath.

I am now going to suppose that we have a relatively long rectangular parallelepiped formed from a single-crystal specimen of pure iron or of silicon-iron. Let us first consider what we might expect to see on the upper surface when the material is in the unmagnetised state and we examine it by the Bitter-figure technique. If the surface is strained, we shall see a wonderful maze pattern which is simply characteristic of strain and which is easily reproducible; i.e., however often we magnetise and demagnetise the specimen, we always recover the same maze pattern. Moreover the pattern is easily reversed, i.e., black becomes white in the pattern, by the application of a small magnetic field perpendicular to the surface. With an unstrained surface, identical patterns are never obtained with successive demagnetisations.

Next, if the unstrained surface is unblemished and is a true crystal plane, we shall see comparatively few deposits; we may occasionally observe a 180 deg. boundary and a few "daggers" or spikes near the edges of the specimen. If there is an inclusion or a tiny pit in the surface, we shall find peculiar patterns. Generally, however, the surface is not a true (100) plane and we observe a complicated "fir-tree" pattern. This structure was very beautifully explained by H. J. Williams, R. M. Bozorth, and W. Shockley* in a paper remarkable both for its elegance and its range of new facts. The trunks of the "fir-trees" are here 180 deg. boundaries, while the branches are special closure domain patterns, formed as it were by shallow, ellipsoidal-shaped closure domains running out from the walls of the principal main domains and intersecting the surface. The sole purpose of these closure domains is to prevent as much magnetic flux as possible from leaving the surface. They do not, of course, produce complete flux closure.

QUANTITATIVE ASPECTS OF DOMAIN STRUCTURE

It is often helpful in dealing with domain theory to have in mind a scheme of magnetisation processes suggested by Néel. Starting with the view that in an unmagnetised iron crystal each domain vector is aligned parallel to one of the six directions represented by the cube edges and their extensions in the negative directions, we picture a six-phase state of magetisation, termed Mode I magnetisation. When we apply a small external field to the crystal, supposing the latter to be ellipsoidal in shape both for convenience and for ease in understanding, then before an effective field can be established *inside* the crystal three of the phases must disappear, because otherwise they would entirely oppose the internal field; we are then left with a three-phase, or Mode II, magnetisation. On increasing the applied field further, we can really establish a field *within* the crystal itself, and eventually make one of the remaining phases so unfavoured that it fades away, so leaving only a two-phase or Mode III magnetisation. Finally, as the applied field is increased without limit, a single-phase, or Mode IV magnetisation alone can exist.

Nickel is extraordinarily sensitive to strain. Now, in Nottingham, we have paid much attention to obtaining nickel surfaces as nearly as possible true crystal planes and we took reasonable care, as we thought, to avoid straining them. However, from some work published in Japan by M. Yamamoto and T. Iwata, in 1953, it appears that we should have discovered much more about the domain structure of nickel if we had confined our attention to less perfectly shaped but very much more carefully annealed crystals.

THE EFFECTS OF INCLUSIONS

As a result of the powder technique, we are quickly learning the important part which small inclusions such as impurities, small defects such as accidental pits, or deliberately-made tiny deformations may play in magnetisation processes. Let us consider, for example, the effects which a small inclusion in the shape of a square may have upon the magnetisation of the main domain configuration in which it is situated. As Néel first showed, we cannot admit that free poles may form over its sides, for otherwise the magnetostatic energy associated with them would be, relatively speaking, enormous. Consequently, a system of closure domains must form around the inclusion.

* See *Phys. Review*, vol. 75 (II), p. 155 (1948).

EXPERIMENTS WITH POLYCRYSTALS

Metallurgists may possibly become impatient with the many references made to work with single crystals only, and may wonder whether polycrystalline material is ever investigated. Relatively few experiments have been made on polycrystalline material, because a specimen must possess a grain structure sufficiently coarse to allow reasonably undisturbed powder patterns to be formed, and it is advisable that individual grains subjected to examination should have a crystal plane in the surface of the specimen.

Among recent experiments are those of U. M. Martius, K. V. Gow, and B. Chalmers, who photographed the behaviour of domain walls in the neighbourhood of grain boundaries in a bicrystal of nickel. L. J. Dijkstra and U. M. Martius examined the changes in the domain pattern of grain-oriented silicon-iron with large grain-size when the specimen was put under various tensions within the elastic range. They found that at a load of approximately 1 kg. per square millimetre, the original domain pattern vanished, and that after a transition stage with increasing load a new stress-induced domain pattern appeared. E. A. Nesbitt and H. J. Williams obtained patterns on polycrystalline Alnico V (Alcomax) in an attempt to explain the mode of action of a magnetic field applied during heat-treatment of such materials.

We recently tried to see how far patterns found on polycrystalline surfaces had their counterpart in patterns on single-crystal surfaces. It was found that the patterns give clear indications of the orientations of the polycrystal grains. With adjacent grains of closely similar orientation (as Chalmers and his collaborators found), the patterns are often continuous from one grain to the other, while grains of widely differing orientations have distinctive patterns, with a sharp line of demarcation at the grain boundary. We were able to compare the spacings of a lace pattern on single-crystal and polycrystalline specimens of approximately the same thickness and we found good agreement.

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"ASTRONOMY" AT THE SCIENCE MUSEUM

A picture, representing "Astronomy," painted by Mr. A. R. Thomson, R.A., has now been hung in the main entrance hall of the Science Museum, South Kensington, London, S.W.7, where it cannot fail to attract the attention of every visitor. In the centre foreground, Galileo is shown using his small telescope and overshadowing him is a representation of the 200-in. reflector of Mount Palomar Observatory, in California. The picture thus illustrates the earliest and latest stages in the development of the optical telescope. The background of the picture indicates some of the zodiacal constellations and other celestial objects. It had been hoped to show the picture in the Royal Academy summer exhibition this year, but the great size of the canvas, which measures 24 ft. by 15 ft., made it impracticable to exhibit it at Burlington House.

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GAUGE AND TOOL MAKERS' ASSOCIATION

Fourth Exhibition

The fourth in a series of Gauge and Tool Exhibitions organised by the Gauge and Tool Makers' Association of Great Britain is to be held at the New Horticultural Hall, Westminster, London, S.W.1, from Monday, May 17, to Friday, May 28, this year. Products exhibited will include: gauges, measuring instruments, jigs and fixtures, special tools, press tools, moulds and dies, portable power tools, diamond tools, and testing machines; and nearly 100 of the 300 companies in the Association will be represented. An advance edition of the Exhibition Catalogue (2*s*., post free) may be obtained from the offices of the Association at Standbrook House, Old Bond-street, London, W.1.

THE SAFETY OF ELECTRICAL EQUIPMENT

In a paper entitled " Safety in the Use of Portable and Transportable Electrical Equipment in Industry," which was read at a meeting of the Utilisation Section of the Institution of Electrical Engineers on Thursday, April 22, Mr. J. W. Bunting expressed the opinion that alternating current at 415 volts three-phase and 240 volts single-phase could not necessarily be used with impunity on portable and transportable electrical equipment. The engineer therefore needed to know what constituted dangerous shock conditions so as to be able to compromise between perfect safety (which would require a voltage so low or a protective device so elaborate as to be utterly impracticable for a machine requiring any appreciable amount of power) and the rival claims of an efficient, simple and economical supply.

The Annual Report of the Chief Inspector of Factories for 1951 showed that two-thirds of the electrical fatalities occurring during that year took place at voltages below 250 and that of this number 80 per cent. were associated with portable equipment. Faulty earthing was responsible for 79 reportable accidents of which 13, all arising from portable or transportable equipment, proved fatal. Moreover, this class of equipment accounted for more than a third of the total of 530 non-fatal reportable accidents. These examples showed that there was grave danger to life if the exposed metalwork of portable or transportable equipment became alive at 240 volts. For whatever the cause of the fault the cause of the fatality was excessive voltage. The most obvious way of reducing the danger was therefore to reduce the supply voltage or, if this was not practicable, to arrange for the duration of the fault to be limited to a few milliseconds, so as to safeguard against fibrillation of the heart. As the various devices for limiting the fault duration depended upon the continuity of the earth path, recourse to the second alternative necessitated continuous monitoring of the earth core.

PRACTICAL RECOMMENDATIONS

With these considerations in view the author recommended that for portable hand lamps the alternating current supply should be at 25 volts with a maximum of 12·5 volts to earth, no earth core being necessary in the flexible cable. For portable tools a 110-volt supply, taken either from individual local transformers or preferably from a 110-volt ring main, should be used. In normal industrial situations an extremely high degree of safety would be obtained by directly earthing the mid-point of the transformer secondary winding. In a boiler house or other location where men might be working inside metal tanks it might, however, be desirable to earth the mid-point through the trip coil of an earth leakage indicator using the Butcher system.

An earth monitoring device, in which the earth circuits were electrically interlocked so that the supply could not be switched on or maintained unless the earth and auxiliary cores through the flexible cable were intact and properly connected, should be used on transportable tools. Wherever possible this form of protection should be permanently installed rather than used in portable form. None of the above measures should, however, be regarded as being sufficient in itself to assure the safety of the user. Good equipment, well-maintained, was essential and careful records of insulation and earth resistance could be a great help in anticipating and obviating potential faults.

COAL-BURNING GAS TURBINE FOR LOCOMOTIVES

FUTURE TESTS AND OPERATIONAL ECONOMICS

Concluded from page 564

When the Allis-Chalmers 4,250-h.p. gas turbine was inspected at the conclusion of the 750-hours test, it was found that the first four rows of both cylinder and rotor blading required replacement. The American Locomotive Company undertook the responsibility of providing the new blading. After considering the various methods of producing blades, and the materials from which they might be made, the following decisions were reached by the Operations Committee.

The stator blades originally supplied in the turbine were precision-cast from alloy S-590 (see Table III for the composition of turbine alloys). The blading was fabricated by assembling groups of individual blades into 90 deg. sections and welding them on the inner radius to S-590 rings. These rings were later machined to receive the inter-stage packing glands. The blades were welded to each other on the outer radius, and the assembly was then machined to the final dimensions. It was found that enough S-590 material was available to allow casting of the cylinder blades. The Howard Foundry of Milwaukee had cast the original blading for the Allis-Chalmers Company, and the dies were available. Consequently, ALCO contracted with Howard for the new blades.

TABLE III. *Composition of Principal Gas-Turbine Alloys*

Elements	Percentage of Each Element in Alloy				
	S590*	Inconel X	Incoloy†	19-9-DL‡	347
Cobalt ..	20·0	—	—	—	—
Chromium ..	20·0	15·0	19·22	19·0	18·5
Nickel ..	20·0	73·0	32·36	9·0	11·0
Molybdenum	4·0	—	—	1·25	—
Tungsten ..	4·0	—	—	1·25	—
Columbium ..	4·0	0·8	—	0·4	0·7
Titanium ..	—	2·5	—	0·35	—
Carbon ..	0·4	0·04	1·0	0·3	0·07
Aluminum ..	1·65	0·8	—	—	—
Silicon ..	0·65	0·3	1·0	0·5	0·5
Manganese ..	0·75	0·5	1·5	0·75	1·0
Iron	24·6	7·0	40·2	67·2	68·2

* New stator blades and rings.
† New rotor blades.
‡ Separator shell and tubes.

New inner blade rings were also required, since the original rings could not be rewelded with any expectation of maintaining the necessary close tolerances. Drawings for the rings, and the original welding fixture, were made available by the Allis-Chalmers Company and production was undertaken at Dunkirk. The rings were forged in quadrants and rough machined, after which the individual blades were welded to the segments. After the necessary heat treating for stress relief, the welded quadrants were shipped to ALCO's Auburn plant, where machining of the rings was completed. The finished segments were installed in the cylinder blade sections of the turbine, caulked in place, and machined clean.

The original rotor blading in the turbine was machined by the Allis-Chalmers Company from S-590 bar stock. Precision casting had been considered, but was ruled out when tests showed that cast blades did not possess the required ductility at 1,300 deg. F. Forging was also considered, but S-590 proved to be too tough at forging temperatures. Consequently, the blade shapes were developed by machining and the roots were produced by " crush grinding."

After giving careful consideration to the selection of both materials and production processes for the rotor blades, the Operating Committee decided to use 19-9-DL, since it is an alloy which is readily available, and with which ALCO had a background of experience. Careful consideration was given to the possibility of using Inconel X, because of its great strength; but high cost and limited availability of this material and the anticipated machining difficulties were important factors in reaching the decision to use 19-9-DL.

ALCO decided to manufacture the rotor blades by broaching the roots and then generating the air-foil sections on a Hydrotel machine. The Allis-Chalmers Company lent a finished fourth-row blade for use as a master. Square bar stock was first cut to length and excess material milled off, giving parallel surfaces by which the unfinished blade could be held in subsequent operations. The root outline was produced by milling, and the root formed to the final dimensions by broaching. The blade contours were then generated four at a time; some finishing work was required to complete the blades.

ALTERATIONS IN TEST PLANT

When plans were laid for the forthcoming turbine tests, the Operating Committee decided to alter the test plant by eliminating the regenerator. The primary purpose was to enable the performance of the simple open-cycle plant to be determined and a secondary consideration was facilitating inspection of the turbine blading at frequent intervals. It was recognised that removal of the regenerator would increase the fuel consumption of the turbine at its most efficient load, about 3,200 h.p., but it was also expected that the maximum capacity of the machine would be increased by approximately 300 h.p. by eliminating the pressure drop caused by the regenerator. The speed range of the turbine during the 750-hour test proved to be considerably less than had been originally anticipated, and for that reason the regenerator had not given the expected reduction in low-load fuel consumption. Likewise, the pressure ratio at maximum speed proved to be approximately 6·0 to 1, or considerably more than the 4·5 to 1 which was originally planned, and which would have given optimum performance with the regenerator. The value of a regenerator for locomotive service with low cost fuels is largely dependent upon reducing the first cost and maintenance cost of the regenerator to a very low figure.

FUTURE OPERATION OF TURBINE TEST PLANT

The 750-hours test showed that the L.D.C. experimental locomotive-type gas turbine could carry its full load on coal, and that the coal-fired operation of a large gas turbine did not differ in any important characteristics from the operation of the same turbine on oil. After the preliminary operating troubles were eliminated, the coal feeding and pumping equipment functioned well, and the combustion equipment was adequate. The ash-removal equipment, on the other hand, did not measure up to its requirements, thus causing the blade damage mentioned above. The forthcoming tests will be devoted primarily to determining whether the new multi-tube fly-ash separators can protect the turbine blades to the extent needed to give adequate life to the turbine.

After the plant has been checked with oil, and the expansion readings, etc., have been taken, an oil-fired test will be run during which fly ash of known characteristics will be fed through the burners into the combustors, using the coal pump as a pressurising means. Calibration tests will be run on a single separator tube to determine exactly how much of the fly ash should be caught, and how much of the finer particle sizes can be expected to pass through a 10-in. Dunlab

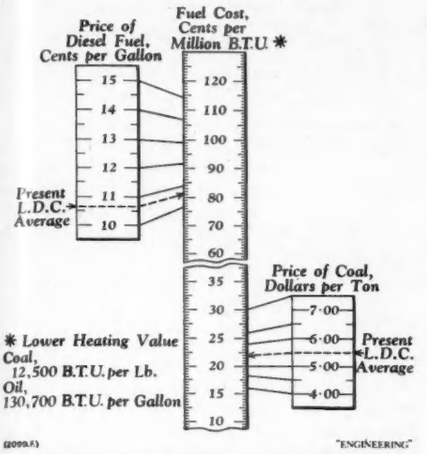

Fig. 6 Economic justification for a locomotive gas turbine which burns coal. A million B.Th.U. in the form of coal cost 22 cents; in the form of Diesel fuel they cost 86·5 cents.

separator. The performance of the complete separator system will then be checked by taking samples of the air entering and leaving the separator, and also by weighing the amount of ash caught by the separator. If this test proves that virtually no +20 micron material is entering the turbine, coal-fired operation will be undertaken.

The next coal-fired operating period is expected to be at least 250 hours in duration. This will proceed in 10 to 15 hour operating periods, with the turbine inlet temperature held at approximately 1,250 deg. F. and the turbine speed as required to maintain at least 3,000 s.h.p. Coal consumption will be determined frequently by weighing, and compressor air flow will be measured continuously by means of the Venturi air flow-meter in the inlet duct. Separator efficiency will be checked at frequent intervals by weighing the amounts of dust collected at the sampling stations located at the inlets and outlets of the separators. In addition, the erosiveness of the ash will be checked continuously.

Whenever the turbine is shut down and cooled off, photographs of the first-row blading will be taken by means of a special camera equipped with a 60-second developing back, so that the appearance of the blades can be checked immediately. The performance of the turbine will be checked at hourly intervals, using the heat-balance methods developed during the 750-hours test. The first evidence of erosion during that test was the falling off of turbine inlet pressure at a given turbine speed and inlet-air temperature. During the next tests, the air flow to the turbine will be measured continuously and it will be possible to keep an hour-by-hour check upon the condition of the turbine blades. Operation of the separator will be checked continuously, by means of the blowdown manometers connected to each tube. Frequent checks will also be made of the weight of ash removed during a given period.

ECONOMIC CONSIDERATIONS

When the Locomotive Development Committee began their work in 1945, the member railroads were paying, on the average, 3·30 dols. per ton for coal and 6·8 cents per gallon for Diesel fuel. Since 1945, prices for all locomotive fuels have risen – coal to an average of 5·50 dols. per ton (66 per cent.), Diesel fuel to 10·6 cents per gallon (52 per cent.). Fig. 6 shows that a million B.Th.U. in the form of coal now cost 22 cents; in the form of Diesel fuel the cost is 86·5 cents. The lower heating value is used for Fig. 6, since the specific fuel consumptions of both gas turbines and Diesel engines depend upon heat released in combustion without condensing the water vapour formed by burning the hydrogen in the fuel – about 5 per cent. for coal and 15 per cent. for oil. Most fuel economists agree that the increasing demand for all kinds of petroleum products will force distillate fuel prices upward. The price of coal is not expected to rise as rapidly.

The fuel consumption of a typical three-unit 4,500-h.p. Diesel-electric locomotive power plant ranges from about 10 gallons per hour at idling to 270 gallons per hour at full power. The L.D.C. gas turbine, during its 1952 tests with the regenerator in place, required about 1,400 lb. of coal per hour at idling (80 deg. F. ambient air, 1,000 ft. altitude). At maximum load, 4,250 s.h.p., the coal consumption was 4,300 lb. per hour. During the forthcoming test programme, without the regenerator, the net power output will rise to a maximum of 4,500 h.p. at full load.

The hourly fuel consumption of a working locomotive depends upon its load factor, which is defined as:

$$\text{Load factor} = \frac{\text{work actually done per hour}}{\text{work done per hour if plant ran at full load}}$$

Table IV shows the fuel consumptions of 4,500-h.p. locomotive power plants for various load factors. Assuming that the average speed for freight locomotives is 21 miles per hour, fuel consumption per mile can be estimated with the results shown in Table IV. At 50 per cent.

TABLE IV. *Fuel Consumption Per Hour and Per Mile of 4,500-h.p. Freight Locomotives; 21 Miles Per Hour*

Load Factor, per cent.	45	50	55	60	65	70
Diesel-electric:						
Fuel rate:						
Gal. per hour	125·1	128·2	151·2	164·4	177·2	190·2
Gal. per mile	5·96	6·58	7·20	7·83	8·44	9·06
Gas Turbine (no regenerator)						
Coal rate:						
Lb. per hour ..	2,900	3,160	3,460	3,720	3,940	4,100
Lb. per mile ..	139	151	165	178	188	196

load factor, a three-unit 4,500-h.p. Diesel-electric locomotive will use about 6·6 gallons per mile; a gas turbine without a regenerator would burn about 151 lb. of bituminous coal per mile.

The fuel cost per mile at present fuel prices and 50 per cent. load factor is about 0·42 dol. for a coal-burning turbine, and 0·69 dol. for a Diesel. For annual mileages of 84,000 miles, the coal bill for the gas turbine would be 35,000 dols.; the fuel oil bill for the Diesel would be 58,500 dols. The effect of rising fuel prices can be estimated from Fig. 7. If coal rises to 6·00 dols. per ton for the conditions outlined above, the annual coal bill would go up to 38,200 dols. If Diesel fuel goes to 12 cents per gallon, the annual cost would be 66,000 dols.

GAS-TURBINE LOCOMOTIVES ON THE UNION PACIFIC RAILROAD

After demonstrations in 1950 and 1951 with a General Electric single-unit oil-fired gas-turbine locomotive, the Union Pacific Railroad ordered ten of these locomotives, Nos. 51 to 60. The first of these was placed in service on January 30, 1952; the last on August 25, 1953.

With the exception of No. 57, which is running on propane, and No. 60, which is burning a selected distillate fuel, the Union Pacific gas-turbine locomotives are operating on a specification heavy fuel oil. The propane-burning locomotive is operating over 334 miles between Los Angeles, California, and Las Vegas, Nevada. During its first six months of operation, this locomotive averaged 10,000 miles (30 trips) per month. The nine oil-burning gas turbines have been averaging 8,740 miles and 380 turbine hours per month. Operations have not been free from troubles, but the difficulties have not been major.

TABLE V. *Miles and Turbine Hours for Union Pacific Railroad Oil-Burning Gas Turbine Locomotives to December 1, 1953*

Locomotive Road Number	Date Placed in service	Total Miles Accumulated	Total Hours Accumulated	Speed, Average Miles per Turbine Hr.
51	1.31.52	195,292	8,549	22·8
52	4.9.52	181,845	7,815	23·2
53	5.7.52	169,174	7,149	23·6
54	6.4.52	161,535	6,021	23·0
55	7.9.52	159,054	6,772	23·4
56	8.13.52	133,315	5,623	23·7
57* ..	5.20.53	59,765	2,494	23·8
58	7.3.53	32,257	1,439	22·4
59	8.12.53	32,951	1,490	22·1
60	8.26.53	28,987	1,306	22·1
Total ..	—	1,154,175	49,658	Av.23·1

* Locomotive No. 57 burns propane.

Table V outlines the miles and turbine hours run by these locomotives up to December 1, 1953; the average miles per turbine-hour operated was 23·1. To date, the Union Pacific has not released any data relative to the operating and maintenance costs. It is, however, felt that the general operations are satisfactory, especially when considering that this is the first major installation of gas-turbine locomotive power. In general, it is to be concluded that the operations of the General Electric oil-fired gas turbines on the Union Pacific clearly indicate that a gas turbine can be successfully operated as a piece of railroad motive power and is deserving of further consideration and development, especially in conjunction with the use of a low-cost fuel such as bituminous coal.

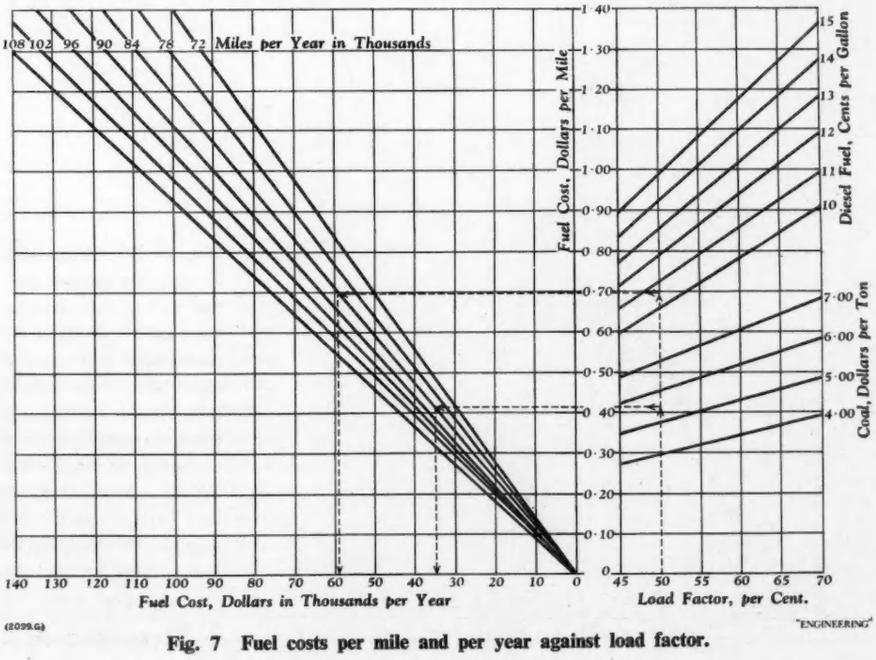

Fig. 7 Fuel costs per mile and per year against load factor.

ASSESSMENT OF PARTICLE SIZE

DETERMINATION OF TWO PROFILE PARAMETERS FOR IRREGULAR SHAPES

By H. H. Watson and A. J. Cruise

Microscopic examination and " sizing " of solid particles, particularly in the size-range less than 20 μ, is a necessary procedure in many fields of research and industrial control. Some types of particles possess a regular shape (spheres, perfect crystals), while many other types are very irregular. We consider the term " shape " to be an attribute of the totality of a particle, and use the term " profile " for the cross-sectional projection as seen, for instance, under the microscope.

The work to be described is part of a research carried out two years ago, directed initially towards a study of airborne particles of coal dust sufficiently small (less than about 10 μ in size) to penetrate to the lung alveoli when inhaled, and so to predispose to an industrial pneumoconiosis. We shall in this paper consider the measurement of only small ($< 15\ \mu$) particles. The techniques to be described have, however, been applied to larger particles (of screen size) and also to macroscopic lumps of material. The object is to determine what factors, or " Profile parameters," must be applied to simple linear measurements in order to assess the true size of a particle.

The actual two-dimensional image seen in a microscope depends on a number of factors, among which are: (*a*) orientation of the particle on the microscope slide; (*b*) method of mounting; and (*c*) optical system, as it affects magnification, resolution, contrast and depth of focus.

Little information can be obtained of the third-dimensional features of a particle, and if the depth of focus is small the true silhouette will not necessarily be seen at one position of focusing. In fact, the optical section clearly in view is little more than the equivalent depth of focus of the objective.

SIZE DEFINITIONS

A number of different conventions have been used to define the size of an irregularly shaped particle. Such are: (i) the Feret diameter; (ii) the Martin diameter; and (iii) the mean-projected diameter, all of which are defined as shown in Fig. 1. The first two are only valid statistically; the third refers to the size of an individual particle and is usually estimated visually by comparison with a series of circles of known size inscribed on an eye-piece graticule. Heywood[1,2] has investigated the inter-relationships of these three diameters. It was he who proposed the use of mean-projected diameter, which is defined as the diameter of a circle of area equal to the projected area of a particle, with the restriction that the particle is viewed in its position of maximum stability, and so is in general presenting its maximum profile. However, the wide variety of outlines of particle profiles, leads to the expectation that a particle profile cannot be uniquely defined by a single linear dimension, such as the mean-projected diameter.

THE FIRST PARAMETER

Heywood[1] therefore introduced a profile factor, α, which is defined as the ratio of the profile area, A, to the area of the bounding rectangle, of length L and breadth B. This rectangle is constructed so that B is the distance between the closest parallel tangents that can be drawn to touch a profile. By definition, and in general, $L > B > T$, where T is the thickness, defined as the distance between two planes touching the particle.

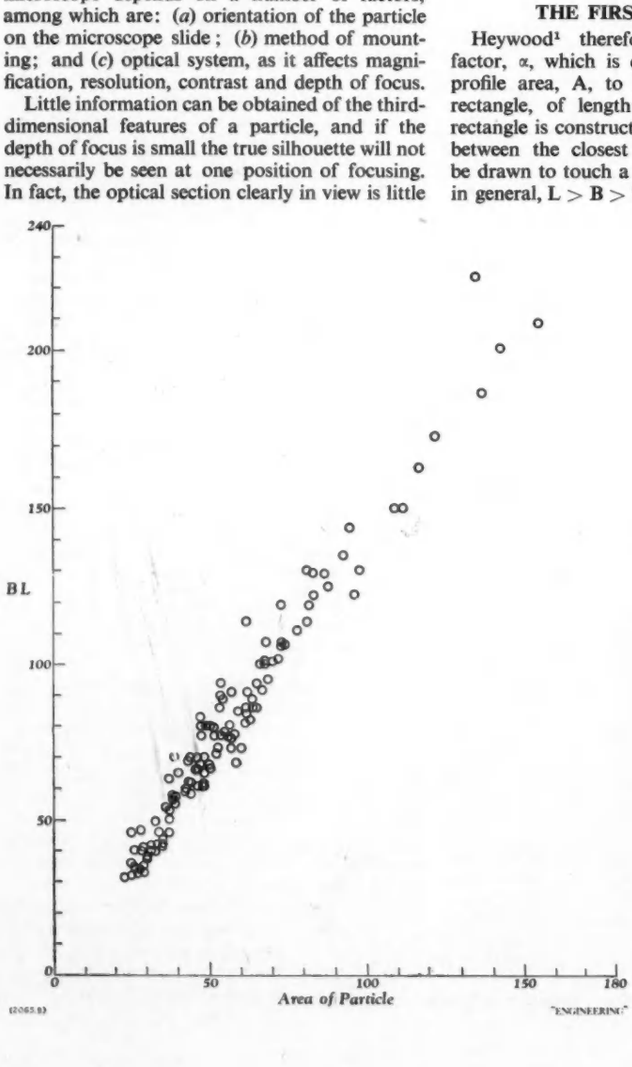

Fig. 2 The relationship between the particle area and that of the enclosing rectangle. Plotted for loose coal dust from a mine floor. The particle area was determined photo-electrically and the enclosing rectangle was defined as in Fig. 1 (lower left). The points fall about a line which can be extrapolated back to the origin. The value of $\frac{\text{Area}}{\text{BL}}$ is the parameter α.

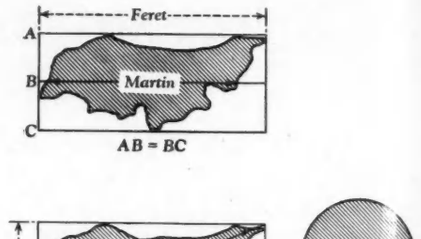

Fig. 1 The conventional definitions for sizing irregular-shaped microscopic particles. Feret and Martin sizes are only useful statistically. The distance " B " is the least that can be drawn.

We may write, therefore,

$$\alpha = \frac{A}{L\,B}. \quad . \quad . \quad . \quad (1)$$

If dp is the mean projected diameter,

$$\frac{\pi\, dp^2}{4} = A, \quad . \quad . \quad . \quad (2)$$

and

$$dp = 2\left(\frac{\alpha\, L\, B}{\pi}\right)^{\frac{1}{2}}. \quad . \quad (3)$$

Heywood[1] has reported some mean values of α for a number of rocks, using fragments of macroscopic dimensions (1·5 to 3 in.). The mean values for the different types of materials are quoted in Table I. No information is given on the range of values obtained for an individual substance, or on values for particles of a microscopic size. The shape groups refer to the three-dimensional forms of the fragments.

TABLE I.—*Values of* α *(after Heywood)*

Shape Group	Range of Means for Different Substances	Overall Mean
Rounded ..	0·72–0·92	0·77
Sub-angular ..	0·65–0·85	0·77
Prismoidal ..	0·50–0·90	0·75
Tetrahedral ..	0·50–0·85	0·73

THE SECOND PARAMETER

A little consideration will show that different profiles can have the same value of α, and so this is not a unique parameter. The value for a circle, or for ellipses of any eccentricity, is $\frac{\pi}{4}$; for a square, or for any rectangle, it is 1·0. We can introduce a feature of uniqueness with a function of the ratio of L to B. One possible way is defined in Eqn. (4).

$$\beta = \frac{dp}{\theta}, \quad . \quad . \quad (4)$$

where $\theta = (L^2 + B^2)^{\frac{1}{2}}$ or the diagonal of the rectangle containing the particle.

We may write

$$\beta = 2\left(\frac{A}{\pi}\right)^{\frac{1}{2}}(L^2 + B^2)^{-\frac{1}{2}}$$

$$= 2\left(\frac{\alpha}{\pi}\right)^{\frac{1}{2}}\left(\frac{L}{B} + \frac{B}{L}\right)^{-\frac{1}{2}}. \quad . \quad (6)$$

also

$$\beta^2 = \frac{4\,\alpha}{\pi}\left(\frac{L}{B} + \frac{B}{L}\right)^{-1}. \quad . \quad . \quad (7)$$

Values of α and β have been determined for a number of dusts in the size range 2—15 μ.

EXPERIMENTAL PROCEDURE

Samples of dust or powder were collected on glass surfaces, and examined with a Vickers projection microscope at a magnification of × 1000. The translucent screen of the microscope was replaced with a plate of clear glass on which was laid a sheet of "glassine" tracing paper. The outlines of individual particles were traced with a sharply pointed hard pencil. This gave a line approximately 0·2 mm. thick and centred as nearly as possible on the boundary of the microscope image. Each particle was fine-focussed throughout its depth so that the maximum profile could be obtained. Some 120 to 150 profiles were traced for each sample, care being taken to avoid selection, except that only unitary particles were traced, aggregates, though few, being ignored. The profile outlines were retraced on to "Graphos" tracing paper and then brushed in with a quick drying matt black paint, to give opaque silhouettes. These were free from thin spots and there was no observable distortion of the tracing paper.

The areas of the profiles were measured photo-electrically, by placing them in turn over the sensitive surface of a suitably illuminated rectifier type of photocell. The cell was placed on a bench in a darkened room and illuminated from the ceiling with a single 36 watt, 6 volt lamp, with voltage control. The paper containing the profile was placed in a simple frame directly over the photo-cell. Each silhouette was produced on an individual piece of paper, of sufficient area to permit a "blank" photo-cell reading for each. The apparatus was calibrated with geometrical areas prepared in the same way and on portions of the same roll of tracing paper. There was a strictly linear relationship between silhouette area and fall in photo-current. The boundary rectangle was then drawn for each particle and values of L, B and θ measured, whence the derived parameters dp, α and β were calculated.

REPRODUCIBILITY

Two series of replication trials were arranged.

(i) Four particles of coal dust were traced, each ten times, five on one day and five the next day; the results are given in Table II.

TABLE II

Particle No.	Area (μ^2)	σ (μ^2)	C.V. (per cent.)	dp (μ)	σ (μ)	C.V. (per cent.)
A.1 ..	8·78	1·08	12·3	3·35	0·21	6·2
2 ..	40·48	2·29	5·7	7·18	0·20	2·8
3 ..	55·18	2·39	4·3	8·38	0·18	2·2
4 ..	81·16	3·01	3·7	10·16	0·19	1·9

σ = standard deviation of a single determination
C.V. = 100 × standard deviation divided by mean

(ii) Twenty tracings of profiles out of the 1,500 or so forming the main series were selected at random, to include at least one from each sample. Each was retraced and a number of parameters re-measured, to give the results in Table III. The range of dp for these twenty particles was 3·5 μ to 10·2 μ.

TABLE III.—*Mean Ratio of Second to First Tracing, with Standard Deviation of Single Value of Ratio*

Parameter	Mean Ratio	Standard Deviation
Profile area (A) ..	1·080	0·054
Length (L)	1·003	0·046
Breadth (B)	1·004	0·069
dp	1·037	0·024
α	1·076	0·087
β	1·038	0·049

The accuracy of the results which follow is probably consistent with the figures given above. Particle diameter (dp) can be assessed over a range of 3 to 10 μ with a standard deviation of about 0·2 μ. This is equivalent to the thickness of the pencil line in the original tracing. There appears to have been a tendency to trace outside a profile. It is interesting to compare the profile area determined as above with the estimate obtained by counting squares. This comparison was made for the 125 particles of dust 1 (*a*) and is shown in Table IV. Each profile was laid over a millimetre grid (ordinary graph paper), and the usual conditions followed.

TABLE IV.—*Comparison of Profile Areas by Photo-Electric and Square-Counting Methods*

Area by Squares (sq. mm.)	Mean Ratio P-E to Squares	σ Single Ratio	No. of Particles
< 40	1·02	0·035	43
40–59	1·01	0·032	36
60–79	1·01	0·023	20
80–99	1·02	0·019	10
> 99	1·01	0·053	16
Overall	1·01	0·029	125

PARAMETERS FOR DIFFERENT MATERIALS

The dusts investigated were:

1. Coal dust, Mine A:
   (*a*) Thermal precipitator sample of airborne dust taken at a coal face.
   (*b*) Loose coal dust picked up from floor of same coal face. Conifuge record of re-dispersed dust.
   (*c*) Coarse coal dust from floor of mine, ground in a laboratory hammer mill. Conifuge of re-dispersed dust.
2. Coal dust, Mine B:
   (*a*) (*b*) and (*c*) as for Mine A.
3. Coal dust, Mine C:
   As (*b*) above for Mines A and B.
4. Fusain from a fourth coal mine.
5. Ground glass.
6. China clay.
7. Ruby mica.
8. Madagascar quartz.
9. Commercial silica.

Dusts 5 to 9 were commercial materials, taken from laboratory stocks; all were re-dispersed as aerosols and collected with a conifuge. A summary of the results obtained is given in Table V. This contains for each dust the mean values of α and of β, and the standard error (σm) of the mean.

TABLE V.—*Summary of Estimates of α and β*

Dust	No. of Particles	Mean α	σm	Mean α	σm
1. (*a*) Coal ..	125	0·690	0·007	0·620	0·004
(*b*) ..	127	0·700	0·005	0·638	0·003
(*c*) ..	1·2	0·593	0·006	0·600	0·004
2. (*a*) Coal .	,48	0·750	0·006	0·670	0·004
(*b*) ..	146	0·767	0·002	0·679	0·007
(*c*) ..	132	0·665	0·002	0·599	0·011
3. (*b*) Coal ..	124	0·675	0·005	0·634	0·004
4. Fusain	143	0·610	0·005	0·536	0·006
5. Glass	130	0·713	0·005	0·649	0·003
6. China clay ..	133	0·693	0·004	0·632	0·004
7. Mica	128	0·663	0·006	0·620	0·004
8. Quartz	150	0·626	0·006	0·582	0·005
9. Silica	127	0·683	0·004	0·631	0·003

In Figs. 2 and 3 are plotted for dust 1 (*b*) the measurements from which the parameters α and β respectively, are calculated. The points for this and also for the other dusts are distributed about a line that, within the limits of experimental error, extrapolates back to the origin. The two derived parameters do not appear to be sensitive to particle size, at least within the limits covered. Errors are seen to be proportional and so regression coefficients have been calculated for relationships of the form

$$A = \alpha (B L)$$
$$dp = \beta \theta.$$

It is the values for α and β so obtained that are entered in Table V together with the standard errors of those coefficients.

We may estimate β from α, using equation (7). This has been done for the various dusts, taking the respective mean values of α and of the ratios of length to breadth of the enclosing rectangle. The comparison between the mean values of β

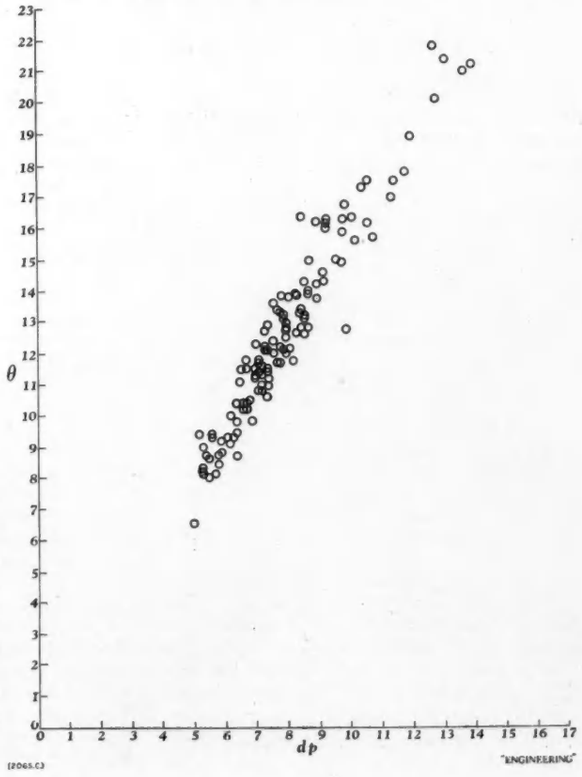

Fig. 3 The relationship between the mean projected diameter and the diagonal of the rectangle. Plotted for same dust as Fig. 2. The definitions of dp and θ are as in Fig. 1. As in Fig. 2, the points fall about a straight line through the origin, showing that the parameter $\beta = \left(\frac{dp}{\theta}\right)$ is also independent of particle size over the range considered.

derived in this way and the experimentally-determined mean values is presented in Table VI.

TABLE VI.—*Comparison of Mean Values of β*
(*a*) From Equation 7
(*b*) Direct determination

Dust	Mean $\frac{L}{B}$	σm	Mean β		Ratio $\frac{(a)}{(b)}$
			(*a*)	(*b*)	
1. (*a*)	1·449	0·032	0·641	0·620	1·03
(*b*)	1·497	0·025	0·642	0·638	1·01
(*c*)	1·402	0·020	0·598	0·600	1·00
2. (*a*)	1·421	0·023	0·672	0·670	1·00
(*b*)	1·420	0·026	0·678	0·679	1·00
(*c*)	1·350	0·019	0·636	0·599	1·06
3. (*b*)	1·391	0·023	0·638	0·634	1·01
4.	2·13	0·068	0·546	0·536	1·02
5.	1·48	0·025	0·650	0·649	1·00
6.	1·48	0·022	0·640	0·632	1·0
7.	1·57	0·028	0·618	0·620	1·00
8.	1·66	0·039	0·594	0·582	1·02
9.	1·44	0·033	0·640	0·631	1·01

With the exception of dust 2 (*c*) close agreement is obtained between the mean values of β.

ACCURACY OF RESULTS

The tracing method, though rather laborious, is one that can be used for colourless as well as for opaque particles. Faust and Cooke[3] obtained a measure of profile area of coal particles with a small photocell in the ocular of a microscope. Their method can only be used effectively for opaque particles and does not allow detailed measurement of the various parameters we have considered.

The reliability of our results depends essentially on the skill and accuracy with which the tracings were made. Indications are that the traced profiles were rather larger than the true ones, but, as noted in the text, this error is not considered to be larger than that due to the thickness of the pencil line, corresponding to 0·2 μ at a magnification of × 1,000.

Our very simple photo-electric apparatus appears to be reliable for measuring the profile areas, and there does not appear to be any necessity to use a more complicated system with lenses (e.g., Sendroy and Cecchini[4]).

The results that have been obtained suggest that reliable quantitative estimations of particle profile parameters can be made, and that statistically significant differences for different dusts can be demonstrated. It is perhaps surprising that for the particles in any one dust the α and β values cluster so relatively closely around the mean value for that dust.

The α and β values for the two samples of coal that were ground in a hammer mill, where there was probably additional attrition caused by particles colliding while air-borne within the mill, are both smaller than the corresponding values for the dusts rendered air-borne by mechanical methods of coal mining. The figures confirm the visual impression that the particles in the hammer mill samples were more equi-dimensional (see L/B values) and were smoother than the particles found air-borne in the coal mines.

The good agreement of the two β values presented in Table VI is very satisfactory, a result which gives some confidence in the methods used and in the measurements made.

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RADIO RESEARCH

INVESTIGATIONS ON WAVE PROPAGATION

The report* of the Radio Research Board for 1953, which was published on April 21, when a commendably short interval after the end of the period to which it refers had elapsed, points out that there has been no reason to change this body's policy of devoting a large proportion of their efforts to radio wave propagation over a very wide band of frequencies. The various problems which are being dealt with under this general heading are described in detail; and some information is also given about the work that has been done on germanium diodes and on materials having special radio applications.

IONOSPHERIC "WEATHER"

One of the major studies, which was carried out at the Radio Research Station at Slough, was on ionospheric weather and its effect on long distance radio communication. The basic information used for this purpose consisted of data on local ionospheric conditions which were supplied to the station from observatories in various parts of the world. This information was employed to prepare forecasts six months ahead of transmission conditions for the users of high frequency radio communications. Special "British Zone" charts, which forecast the conditions for circuits terminating in the British Isles, were constructed and will, it is hoped, provide more accurate forecasts than the general charts which have previously been used.

The Slough station has also been using a method of investigating ionospheric conditions by studying long distance back-scatter, or "echoes," from the earth's surface of high power pulses transmitted from the observation point. Sharply beamed aerial systems, directed along fixed azimuths and capable of operating over a wide frequency band, were used for this purpose. A rotating beamed aerial system with restricted frequency coverage was developed for use with a plan position indicator display. Propagation conditions within a circular area of 5,000 km. radius from the observation point are shown on this indicator as the aerial rotates. A camera is arranged to take one photograph at each revolution of the aerial and, by projecting the developed film at a greatly increased speed, a picture is obtained of changes within 5,000 km. of Slough.

A new system of phase measurement, which employs an ultra-high-frequency radio link to convey a phase-reference signal, was completed and was used satisfactorily to study the phase changes which occur in low frequency ground waves as they pass over geological boundaries; or from a path over land to one over water. Such studies are important in connection with those types of radio aids for marine and air navigation which are based on the reception of low frequency signals from fixed transmitters. The results obtained with this system of measurement show that there is a phase disturbance at a coast line which is similar to that found over marked boundaries in geological structure. Phase variations were also found in radio waves passing near, and parallel to, a coast line.

VERY SHORT WAVE WORK

The increasing use of bands with frequencies above 30 megacycles and their importance in the development of television and for other purposes has made the study of the propagation of very short waves important. An investigation was therefore conducted into ground wave propagation over irregular terrain at frequencies of 100 and 600 megacycles and propagation curves for general use were prepared for the 50 to 800 megacycle band. At longer distances a study was also made of the effects of weather conditions on field strength levels. The information gained, together with data supplied by the Post Office and the British Broadcasting Corporation, was employed to draw propagation curves. These curves have been adopted by the International Radio Consultative Committee for use in the appropriate geographical regions.

* *Radio Research* 1953. Published for D.S.I.R. by H.M. Stationery Office, Kingsway, London, W.C.2. (1*s*. 9*d*. net.)

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ROAD TRAILER BODY WITH MOVING FLOOR

Quicker Loading and Unloading

A demonstration showing how a "Jekta" movable floor installed in a trailer van body can reduce the time required for loading and unloading was given on April 12, by Walker and County Cars, Limited, 76 Grove Park-road, London, W.4, at the General Post Office Stores Depot, Palace of Engineering, Wembley.

The trailer body was mounted on an eight-ton Scammel chassis but it can be coupled to any standard road-haulage tractor. Its floor, which measured about 16 ft. by 6 ft. 8 in., consisted of four sections. The rear section was fixed and the other three sections, which were supported on rollers, could be hauled to the rear by a manually-operated mechanism so that they lay one above the other. The mechanism, which is extremely simple, consisted of a hand crank, a reduction gear, and a roller-chain drive coupled to the front floor section. The front section is linked to the other movable sections by rods which are automatically tripped as each section moves into position. A strict sequence is maintained to prevent one section pushing against another and thereby causing damage to the load.

Each section can carry a load of 2 tons and can be hauled to the rear in 30 seconds. The individual sections of the vehicle demonstrated measured 49 in. from front to rear giving an overlap of 1 in., this breadth has been used to accommodate the size of pallet that the vehicle will carry.

A fork-lift truck, model E.420, made by Conveyancer Fork Trucks, Limited, Warrington, was also shown at the demonstration, which was followed by two short films. The first film dealt with the loading and unloading of one of three similar trailer bodies operated by the St. Anne Board Mill Company, Limited, Bristol. These vehicles operate over a distance of seven miles between two factories and since their introduction a considerable saving in time has been made. One vehicle is now doing eight journeys per day whereas a similar vehicle without the Jekta floor made only five. The second film showed the application of the range of Conveyancer fork-lift trucks to mechanical-handling problems in a great many industries.

BROADCAST TRANSMITTERS

OPERATING BETWEEN 174 AND 960 MEGACYCLES

The first of six very high/ultra-high frequency transmitters for experimental work by the British Broadcasting Corporation on Bands III, IV and V, has recently been completed at the Mullard Research Laboratories, Redhill, Surrey. This transmitter is designed for operation on Band III (174 to 216 megacycles). The development work on the remaining five transmitters – another for operation on Band III and two each for use on Bands IV (470 to 585 megacycles) and V (610 to 960 megacycles) – has also been completed and production of the final equipment is well under way. (The full frequency ranges of the transmitters are 174 to 265 megacycles, 470 to 600 megacycles, and 600 to 960 megacycles respectively.)

These transmitters have been developed to a specification laid down by the British Broadcasting Corporation. Although they have been designed to meet these requirements, they could be adapted for use as efficient, small-power television transmitters operating anywhere within the frequency range covered by Bands III, IV and V. It is also possible that the experience gained in their development will be of great value when considering the design of unusually wide frequency-range tunable transmitters for communications and other purposes.

ALTERNATIVE MODULATIONS

One of the main design requirements of the new transmitters was that, for reasons of economy, they should operate at relatively low powers. This meant that the field strengths had to be extremely small compared with those normally associated with broadcast transmitters; and an unusually high order of transmitter frequency-stability was necessary so that narrow-band receivers of extreme sensitivity could be used. To ensure that valid propagation measurements could be made at the receiver, the stability of amplitude also had to be high.

In practice, the transmissions will normally be square-wave modulated. The signals, at a fundamental modulation frequency of 1,000 cycles, will be extracted in the receiver by means of filters. The amplitude of the signal will then be used to provide the propagation record. For investigations of multi-path transmissions and echo effects (factors of significance when operating in the higher frequency ranges) use will be made of the pulse-modulation which is also available.

The chief development features of the transmitters are the wide frequency range of tuning and the fact that only one radio-frequency circuit is used for both pulse and square waveform conditions of modulation. This has been made possible by using variable length, co-axial resonant lines for the output, the preceding and, in some instances, the earlier stages. The equipment is designed so that routine measurements may be made by non-technical personnel. The transmitters are also intended for operation in a vehicle and to ensure reliability they had to be capable of working with large variations in the mains voltage. This has been achieved by designing the power supply unit to operate satisfactorily with single-phase supplies at from 200 to 250 volts, 45 to 55 cycles, with permissible voltage fluctuations of + 5 to − 15 per cent. The power consumption of the equipment is about 3 kVA.

Very high frequency tetrodes are used in the early stages. Common cathodes and screens for the two tetrode sections give high power gain with heater economy. As they also have built-in neutralising capacitors, the circuits could be simplified.

EIGHT-UNIT EQUIPMENT

The equipment, which is designed to feed into a 70-ohm aerial, comprises eight units. These are: a power supply unit; a modulation waveform generator; a frequency generator and multiplier unit; a square waveform modulator; a pulse waveform modulator; a fault alarm and safety unit; a radio-frequency drive unit; and a radio-frequency power amplifier/oscillator unit. They are mounted in two bays of a cabinet, 6 ft. high by 6 ft. 6 in. wide by 2 ft. 9 in. deep. The weight of the equipment is approximately 2,000 lb. The illustration shows the cabinet with the cover panels removed and some units withdrawn.

All units are designed so that they are readily accessible from the front. The power unit is trolley mounted, and all the other units, except the two radio-frequency stages, are carried on retractable runners to facilitate servicing. For the servicing or replacement of the output and driver valves, a hydraulic jack is incorporated in the equipment to raise the heavy upper casing of the valve mounting. The lower casing, in which the valve is mounted, can then be tilted forward and the valve withdrawn.

The equipment has been designed to withstand transport under vibration and shock conditions. All the usual interlocks and safety systems are incorporated to protect personnel and to ensure that adequate safeguards are provided against the overloading of vital valves and other components. A clock is also provided on the front panel so that timing and identification signals can be automatically transmitted at regular intervals.

PERFORMANCE

The six transmitters are designed to work at any frequency within their range and they provide for both square waveform and pulse conditions of modulation. With both types of modulation, the peak power delivered is maintained constant within ± ½db over any two-hour period, after the lapse of a 30-minute initial warming-up time.

The repetition frequency under 100 per cent. square waveform modulation conditions is 1,000 cycles, with quartz-crystal control giving a short-term stability within 0·002 per cent. The change-over edges are of the order of 10 microseconds. The power outputs for the three types of transmitters are: Band III, 150 watts continuous wave, i.e., 600 watts peak; Band IV, 100 watts C.W., i.e., 400 watts peak; Band V, 50 watts C.W., i.e., 200 watts peak. The carrier frequency stability is ± 1 part in 10,000 over a period of 48 hours. This is achieved by frequency multiplication from a crystal-controlled oscillator working in the range 5 to 10 megacycles. Facilities are also provided under the square waveform modulation condition for the signals to be interrupted for 2 to 4 seconds at intervals of 30 seconds, or for 1 to 2 minutes at intervals of 60 minutes, the three operations being controlled by an accurate clock mechanism.

The repetition frequency under pulse modulation conditions is also 1,000 cycles, and is quartz-crystal controlled. The pulse duration is 0·5 microsecond. The peak pulse power under all conditions is greater than 10 kW, and the frequency stability is of the order of ± 1 part in 1,000. This is achieved without resort to crystal control, the output stage being used in the self-oscillating condition.

The dummy load, which is designed for measuring the transmitter output, consists essentially of a short co-axial line filled with carbon tetrachloride, the inner conductor being of a thin gold film on a glass rod. This presents a substantially resistive input impedance of 75 ohms at frequencies from 100 megacycles upwards. The power absorbed is measured in terms of the temperature rise in the carbon tetrachloride cooling liquid. The maximum power handling capacity of the instrument is 600 watts, and the power measurement accuracy is ± 1·5 watts or ± 2 per cent., whichever is the greater.

The transmitter with the front panels removed and with the power, frequency-generator and modulation units withdrawn. The output and driver valve casings are the vertical cylinders in the right-hand section.

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ELECTRICITY SUPPLY IN MARCH

Satisfactory Increase Maintained

During March, 1954, 6,037 million kWh were sold by the British Electricity Authority to the Area Boards, an increase of 10·6 per cent. over the figure for the same month in last year. When corrected for the weather and the number of effective working days, however, the increase was 8·9 per cent., the weather having been slightly colder and there having been more working days in March, 1953. The amount of electricity sent out by the Area Boards during the month was also 6,037 million kWh.

OPPOSED-PISTON TWO-STROKE DIESEL ENGINE

FOR PASSENGER-SERVICE VEHICLES

A new Diesel engine of unusual but simple design, known as the Commer TS3, was shown on May 5, for the first time, at the premises of Rootes, Limited, Lords-court, St. John's Wood, London, N.W.8. Introduced by Commer Cars, Limited, Luton, Bedfordshire, who are one of the Rootes group of companies, it has three cylinders with opposed pistons and operates on the two-stroke cycle. Direct injection is used. The porting is based on Kadenacy principles, and a Root's-type blower assists in scavenging. Each piston is connected to a common crankshaft, which lies centrally below the cylinders, by a rocker arm and two connecting rods, one of which is secured to a piston and the other to the crankshaft, as shown in Fig. 4.

The cylinders have a bore of 3¼ in., the piston stroke is 4 in., and the capacity is 199 cub. in. At 2,400 r.p.m., 90 brake horse-power is developed and the maximum torque is 250 lb.-ft. at 1,200 r.p.m. The engine weighs only 997 lb. giving a good power-to-weight ratio. The opposed-piston layout with piston-controlled ports saves weight by eliminating components such as cylinder heads, valves, tappets, camshaft and pushrods. Although the majority of two-stroke engines give their best performance in the higher-speed range, the makers state that this particular engine also develops a good torque at low speeds. Furthermore, it has been designed to allow for an increased power output in the future.

The TS3 is the first Diesel engine to be made within the Rootes group of companies and its introduction is another sign of the growing popularity of the Diesel prompted largely by the economy which it offers. Both the design and development have been the responsibility of the group as a whole, and now that this stage is complete it is to go into production in the works of Tilling-Stevens, Limited, Maidstone, Kent. The first engines are to be installed in the Commer Avenger medium-weight passenger-vehicle chassis in which it will be mounted beneath the floor of the driver's cab. Until recently, the Avenger chassis has been made in one size only but will now be made in two lengths with wheelbases of 15 ft. 9 in. and 17 ft. 6 in., respectively, the latter being suitable for 8-ft. wide bodywork, and seating up to 39 passengers. The overhead-valve petrol engine previously installed in this chassis will still be made as an alternative. The TS3 will also be available for the Beadle and Harrington chassis-less coaches which seat up to 41 passengers.

UNUSUAL LAYOUT

The unusual layout of this engine makes the operational cycle of particular interest. Each of the three horizontal cylinders contains two pistons which move in opposite directions, one piston controlling the inlet ports and the other the exhaust ports. As the pistons approach mean inner dead-centre, both inlet and exhaust ports are closed and fuel is injected into the combustion chamber, which is formed by the space between the piston crowns, and ignites instantaneously.

As the pistons are driven apart by the combustion the exhaust ports in the liner wall are uncovered by one piston and the burnt gases are allowed to escape. The other piston uncovers the air ports 25 deg. later and air held in a surrounding chest enters the cylinder driving any residual gases before it towards the exhaust ports in a scavenging action. To ensure that sufficient air is retained in the cylinder for complete combustion the exhaust ports are arranged to close a brief period before the inlet ports. The pistons then converge towards mean inner dead-centre and the cycle is repeated. To achieve the correct opening sequence with piston-controlled ports the two opposed pistons have been set slightly out of phase with each other. The firing order is 1, 2, 3.

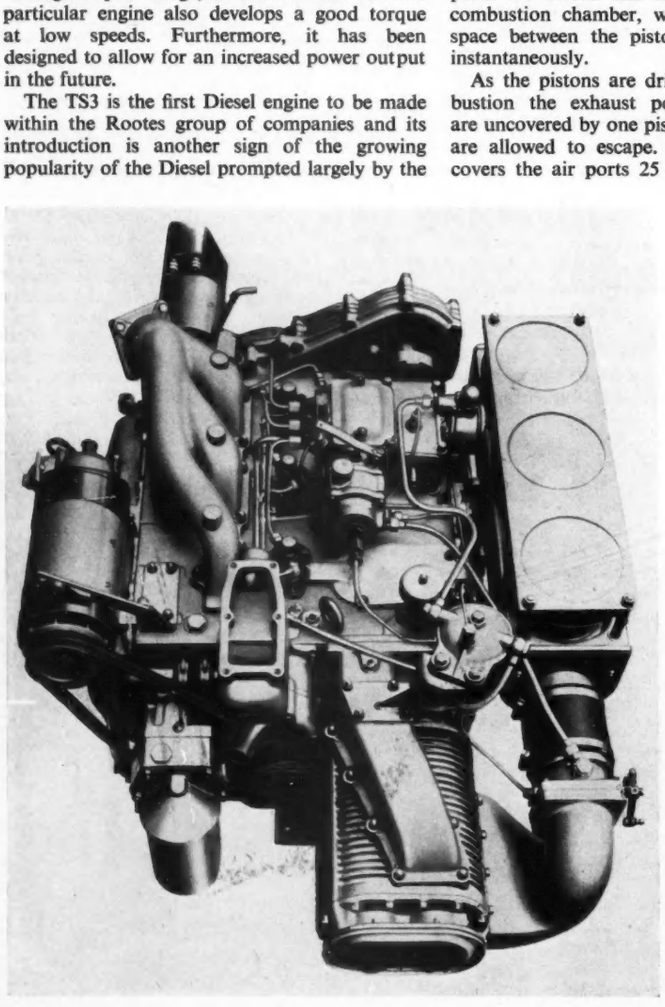


Fig. 1 This Diesel engine, developed by the Rootes group, has been designed to operate on the two-stroke cycle. It has three cylinders with opposed pistons and a C.A.V. direct-injection fuel system. The injector nozzles are of the single-hole type. The view looking down on the engine shows the blower in the foreground and the air filters on the right.

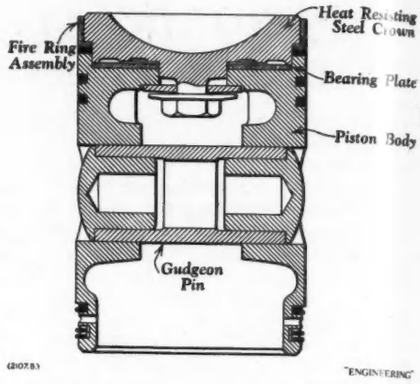


Fig. 2 The piston has a heat-resisting crown and a cast-iron body separated by a special plate, which counteracts the severe conditions of heat flow associated with the two-stroke Diesel cycle.

The design is based on a principle credited to Michael Kadenacy which involves the opening of the inlet ports at the moment when a rapidly outflowing column of gas has been formed and a suction effect is exerted at the inlet port; the products of combustion are cleared rapidly and it is possible to secure high volumetric efficiency in the following air charge. A Root's-type blower, which can be seen at the bottom of Fig. 1, supplies air at a low pressure to the air chest in the cylinder block; the air passes through an oil-bath air cleaner and silencer prior to entering the blower. A partial vacuum is created in the crankcase to prevent oil leaks at oil seals and various joints.

The cylinder block and crankcase are in the form of a single iron casting stiffened by internal webs and into this the three cylinder liners are pressed. The liners are of the wet type cast in a good quality iron and are sealed by means of flexible metallic lips, machined on their outer diameters, which engage with webs in the crankcase casting. This makes the use of sealing rings and joints unnecessary. The inlet ports are cast at one end of the liners and the exhaust ports are machined at the other.

TWO-PIECE PISTONS

Each piston, Fig. 2, comprises a cast-iron body attached to a heat-resisting crown, as shown, the two components being insulated from one another by a special plate to counteract the severe conditions of heat flow associated with a two-stroke engine. The face of the crown which comes into contact with the combustion gases is dished to a nearly hemispherical form. Above the nitrided gudgeon-pin, which has brass end-pads, is a composite fire ring and two wedge compression rings. Towards the base of the skirt there is a stepped air-seal ring and a two-piece scraper ring. The cylinder and piston lubrication is said to be unusually well controlled, and as the scraper rings operate in the part of the bore which receives least wear, that is, on the outer side of the ports, the life of these parts has proved to be exceptionally good.

PROGRESSIVE COMBUSTION AND ELIMINATION OF KNOCK

The inlet ports in each cylinder have been made tangential to the bore to impart a swirling action to the entering air as an aid to mixing and complete combustion. The blower supplies one and a half times the piston displacement of air into the cylinder, a portion being lost in scavenging. Combustion is also assisted by the hot-crown piston which has the effect of reducing the delay period between injection and the commencement of burning, giving smooth progressive combustion and eliminating knock.

HIGH THERMAL AND MECHANICAL EFFICIENCIES

A higher thermal efficiency than that of most conventional engines has been obtained by reason of the smaller heat losses to the cooling system of this type of engine. There is no cylinder head to convey heat away from the combustion zone; only a small portion of the cylinder wall is in direct contact with the combustion zone thus reducing the heat losses to the cooling water; and the heat dissipated through the piston is minimised by the heat-resisting steel crown which insulates it from the cast-iron piston body.

SMALL ANGULARITY OF CONNECTING ROD

Many of the mechanical losses associated with internal-combustion engines have been reduced. The side thrust exerted by the pistons on the cylinder walls is very low due to the small angularity of the piston-connecting rod throughout its stroke. In the more common type of engine the big end of the connecting rod has a throw of about 17 deg. on each side of the centre line, whereas this design requires only 5 deg. angularity. A reduction in friction is also effected by the absence of valves, springs, pushrods and camshaft. In addition, owing to the effective scavenging arrangement, the power required to charge the cylinders fully with air is low.

The forged alloy-steel crankshaft is short, which, allied with the large overlap of crankpin and main bearings, results in exceptional rigidity and eliminates the need for a damper. The crankshaft is fully balanced and supported on four main bearings of the thin-wall steel-backed Babbitt type and the end thrust is taken up by thrust washers. Each piston is connected by a rod to its own rocker lever and then by a connecting rod to the crankshaft. The rods have forked ends linking with the rocker levers and to eliminate out of balance forces the alloy-steel rockers are balanced in pairs. The opposed drive to the crankshaft gives almost perfect balance; consequently the main bearings are lightly loaded. There is no load reversal on the connecting-rod bearings, therefore the more highly-loaded top halves have been lined with copper-lead-indium alloy and the bottom halves with Babbitt metal.

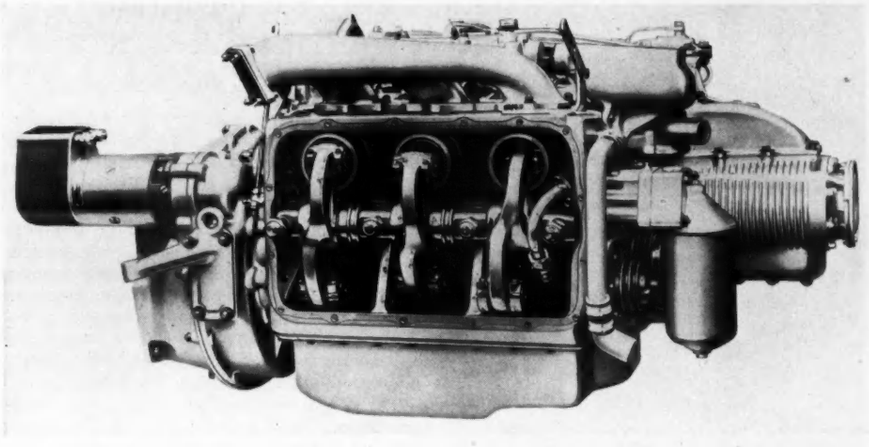


Fig. 3 One of the side covers is removed to show the rockers which connect the piston rod to the crankshaft connecting rod. Withdrawal of the pistons for inspection is simple.

SINGLE-HOLE INJECTORS

An N-type three-cylinder C.A.V. fuel pump is used embodying a fuel-lift pump. It is driven from the rear of the engine by a triplex chain. The pump governor, which is of the pneumatic type, is brought into action by a Venturi-operated device located between the air filter and blower. The fuel-filtering arrangements consist of a combined dirt and water trap between the fuel-lift pump and tank, a fine gauze screen in the lift pump itself, a C.A.V. paper-element filter on the delivery side and felt-block filters in the injection pump. The injectors are of the single-hole type operating at 140 atmospheres.

The lubrication system is fed by a gear pump driven by a single chain from the front of the crankshaft. It supplies the main gallery through a full-flow filter, and before entering the pump the oil is strained by means of a floating filter. Branch drillings from the main gallery supply the main bearings and oil is relayed through the hollow rocker shafts to the rocker centre bearings and to the top and bottom end bushes. The gudgeon pin is fed through a hole in the piston rod and other holes and pipes convey oil to the blower drive, injection-pump drive and chain drive. The capacity of the sump is 28 pints.

The blower has a spring-cushioned quill drive from a triplex chain driven off the rear of the engine. On starting the engine and at low speeds any initial " kick " in the drive is damped out by cushioning the lobes of a cam against spring-steel plates. An ingenious exhauster pump, of aluminium, for maintaining the vacuum in the brake reservoir of the vehicle, is built into the engine. It works on a two-stroke cycle having ports in both cylinder and piston. Its reciprocating motion is obtained from one of the main rocker levers.

Circulation of the cooling water is assisted by a centrifugal pump, with a self-adjusting gland and running on sealed ball bearings and this pump, in conjunction with a 17-in. diameter five-bladed fan, give vigorous water and air flow through a tubular radiator block normally located under the cab floor. A by-pass thermostat regulates the engine temperature and gives unrestricted circulation at 85 to 89 deg. C. The total water capacity of the engine and radiator is 32 pints.

Installed on the side of the block is a 600-watt, 24-volt C.A.V. fan-ventilated dynamo, the output being regulated by a current-voltage system. An axial-type C.A.V. starter motor is used.

The design and layout of this engine make maintenance particularly easy. If decarbonisation becomes necessary, the only operation required is the removal of the exhaust manifold which gives access to the ports for cleaning the apertures; coking-up, however, is said to be very limited. Due to the small side thrust of the pistons the bore wear is slight. To gain access to the main rockers and bearings the removal of the side covers of the engine is all that is necessary, as will be clear from Fig. 3.

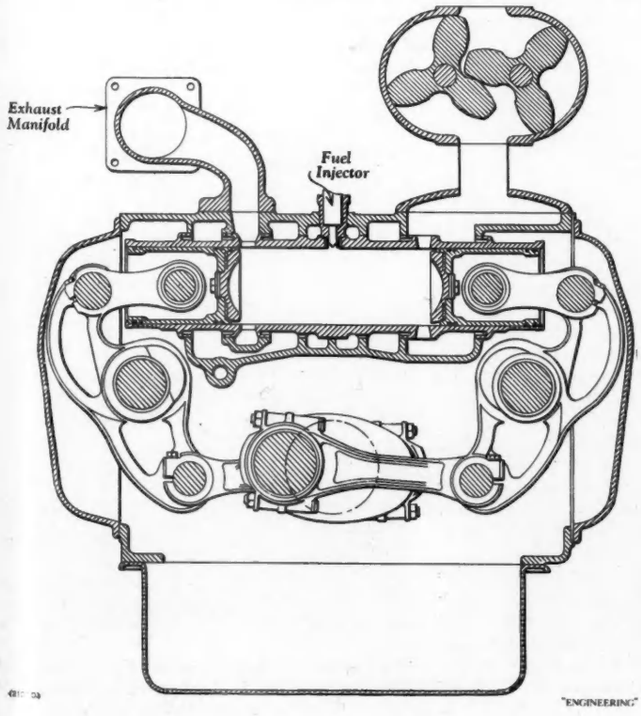
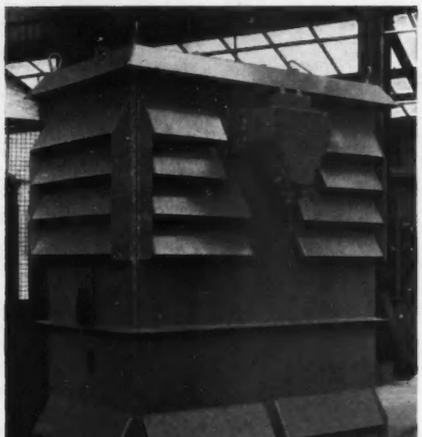


Fig. 4 The unusual layout is shown by this section. The water jacket surrounds the centre section of the cylinder and the small degree of angularity of the piston rod, which is near the end of its stroke, can be seen. The inlet and exhaust ports are uncovered and the blower is shown diagrammatically.



AIR-COOLED TRANSFORMERS FOR OUTDOOR USE

The employment of air-cooled transformers out-of-doors is exceptional. The 300-kVA 11-kV/433-volt units of the naturally air-cooled dry type, which have recently been completed by Transformers (Watford), Limited, Sandown-road, Watford, Hertfordshire, are therefore of interest for the details adopted.

The cores, clamps, winding risers and tapping assemblies have been given special attention to prevent deterioration should the transformers remain unenergised for lengthy periods under a variety of high humidity conditions. Special attention has also been paid to the impregnation of the windings with fireproof material, while the coils and end insulation between the clamps are mounted in such a way that flashovers will not occur when the transformer is first energised in humid atmospheric conditions. In doing this considerable use has been made of porcelain as a constructional material.

Cable boxes are provided on both the high and low tension sides and the transformers have been tested in accordance with British Standard Specification B.S. 171/1936. The appearance of a typical unit is shown above.

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PULLEY WHEEL WITH LOCKING HUB

Split Taper Bushes

A pulley wheel embodying a patented hub, which is known as the "Dualok," has been introduced by the Zerny Engineering Company, Limited, Oppidans-mews, London, N.W.3. The hub has been designed to enable the pulley to be quickly and firmly attached to any shaft. It comprises two split taper bushes, one each side of the hub. They are held in position by Allen-type screws which, when tightened, draw the bushes into the hub until they wedge tightly between the hub and the shaft.

The smallest Dualok hub being made requires a torque of 400 lb.-ft. to move it, although no key is used. This type of hub can also be applied to chain wheels, gear wheels and flat pulleys. The pulley wheel incorporating the hub is being made with belt grooves up to $\frac{7}{8}$-in. wide and in sizes up to 42 in. diameter. It can be fitted with interchangeable bushes which are available in standard sizes for shafts from $\frac{1}{2}$ in. to 4 in. diameter.

REMOTE WINDOW AND VENTILATOR CONTROL

Flexible Cable Operation

A mechanical remote-control system for window and ventilator operation has been introduced by Teleflex Products, Limited, Teleflex Works, Chadwell Heath, Essex. It can be used for operating single lights or long stretches of continuous windows. An example of the latter type of installation that has been installed comprises three stretches of continuous opening windows, each 100 ft. long, all of which are arranged to be opened simultaneously from one control point. The total window load in this installation is 900 lb. and the load which has to be exerted at the "operator" is 15 lb.

The system provides for manual or automatic operation. In the latter method an electric motor is used to drive the operator. The connection between the control point and the window is by a cable carried in a metal conduit. The cable is available in two sizes, $\frac{1}{8}$ in. and $\frac{1}{4}$ in., and is made from high-tensile steel wire. It consists of a central tension-compression core with a continuous-helical outer winding, as that functions as a drive rack. In addition it presents a reduced area of contact to the internal surface of the conduit and results in minimum friction loss. Its construction also gives increased flexibility with a high loading capacity and facilitates the retention of lubricant between the helices and inner winding.

The method used for feeding the cable is interesting. Its helical outer winding engages a toothed wheel. Enclosing both cable and

wheel is a common housing. The wheel can therefore be rotated to impart movement to the cable, or the wheel rotated by the cable as in a rack and pinion. This system is used in two ways: a "straight-lead" where the cable is engaged tangentially; and "wrapped" where the cable is passed around the circumference of the wheel for 180 deg.

A straight-lead rotary unit making use of the first method is only applied in the system where the loads are not excessive, and is used in the remote unit for single-opening lights or coupled in series for operation of window sets. It is also used in intermediate units which are interposed at any point where the control has to be branched and diverted.

The manual operators are made in direct and geared form fitted with a handwheel, hand lever or crank handle and each unit is adaptable to face, flush or panel mounting. They can also be made incorporating either a locking device, a friction-type variable setting, where the control is likely to be affected by creep-back, or a free movement for use with ventilators and windows that are balanced.

To facilitate operation of more heavily stressed control units for use with heavy installations the cable is connected to a rack drive or screw drive designed to withstand high-output loads. A built-in reduction gear keeps the input loads comparatively light.

With the larger installations where extensive use is made of remote-control gear, a motor-driven operating control is usually installed, as previously mentioned. The operator designed for this purpose is controlled by a push-button and is adjustable to any degree of travel by setting a limit switch.

132-kV WOOD POLE TRANSMISSION LINE

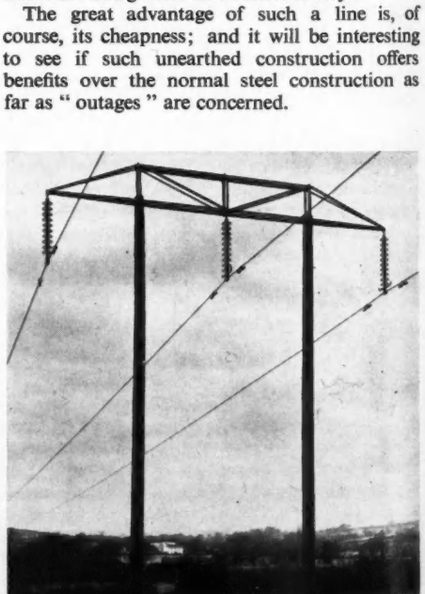
The accompanying illustration shows an unusual use of wooden poles for carrying an extra high-tension electric-power line. This line, which is being erected by British Insulated Callender's Construction Company, Limited, 21 Bloomsbury-street, London, W.C.1, for the British Electricity Authority, is to connect Carmarthen and Haverfordwest in South Wales, a distance of 27 miles. It will consist of a single 132-kV three-phase circuit, which is being suspended from 276 red-fir poles, varying in length from 40 ft. to 53 ft. and in diameter from $10\frac{1}{2}$ in. to 15 in. The normal span will be 600 ft.

The cross arms, which are being assembled on site, are of lattice steel construction, giving a pin-jointed fixing, and are bolted to the tops of the poles prior to erection. The three leg members of the cross frame are arranged so as to give a phase-line spacing of 16 ft. Although there are no brace blocks or trussing tackle, kicking blocks are provided on the intermediate poles to give additional resistance and are attached to each leg 18 in. below ground level.

The three conductors are of 0·175 sq. in. steel-cored aluminium and are made up of an inner core of seven galvanised steel wires overlaid by 30 aluminium wires, each 0·11 in. in diameter. They are being erected to a tension of 4,370 lb. at 40 deg. F. in still air, as against the normal grid tension of 3,253 lb. for this size of conductor. Stockbridge vibration dampers are being fitted to each insulator to deaden the line vibrations.

It was specified that readily available means should be provided for earthing the line during maintenance periods. An 0·1-sq. in. copper strand is therefore being turned six times round the pole butt to provide an earth. This strand terminates in a lug which is arranged so that it can be easily connected to the steel cross arm. Such an easily accessible earth is preferable to the spike earths which would normally be used. To retain the insulation value inherent in the wood pole construction, laminated wood insulators are being fitted in all the line stays.

The great advantage of such a line is, of course, its cheapness; and it will be interesting to see if such unearthed construction offers benefits over the normal steel construction as far as "outages" are concerned.



The 132-kV circuit between Carmarthen and Haverfordwest is to be carried on this simple pylon of two red-fir poles.

LIGHTWEIGHT DIESEL TRAINS FOR BRITISH RAILWAYS

TWO-CAR UNITS TO ATTRACT TRAFFIC

The accompanying illustration shows one of the two-car Diesel trains which are being built by the British Transport Commission for use in six light-traffic areas. As announced on page 200 *ante*, 47 of these units are to be used in the West Riding, West Cumberland, Lincolnshire and East Anglia. In addition, 10 motor-cars and 10 trailers are to be constructed for the Newcastle-Middlesbrough line and six multiple-unit trains and eight spare vehicles for the Edinburgh-Glasgow line. From Monday, June 14, these units will be employed to give a half hourly service on weekdays, between Leeds and Bradford and Harrogate. On Sundays a frequent service will be run between Bradford, Leeds and Knaresborough. They will be used partly in substitution for, and partly in addition to, steam trains with the object of working the services at a lower cost and providing better facilities.

INTEGRAL BODY AND FRAME

The present cars, which were built at the Derby works of British Railways, are 60 ft. 8 in. long over the buffers and a two-car unit has accommodation for 16 first class and 114 third class seated passengers. The body frame, underframe structure and panelling are of light alloy and are designed as an integral unit to combine strength and lightness. The frame members are extruded sections, which have been riveted with light-alloy rivets. The panelling was welded into continuous sheets which extend from door to door and was then riveted to the frame members. The floor consists of extruded sections and forms part of the structure. It is covered with two thicknesses of flameproof hardboard with an overlay of linoleum. The inside of the body and the underneath of the floor is sprayed with asbestos to reduce condensation and noise.

The mild-steel bogies are of conventional design, the bolsters being fitted with spring side control, while the centre tacking and side friction blocks are carried over rubber mountings. The axles are carried on roller bearings. The weight of two cars including 232 gallons of fuel is only 54 tons.

Each motor vehicle is driven by two 125-h.p. Leyland horizontal Diesel engines, which are connected through a torque converter and gearing to one axle on each bogie. The converter is essential for the steep gradients on the West Riding lines, but it has been fitted to every engine as there will be only one motor vehicle in the train units in some areas.

The torque converter is of the Lysholm-Smith type. It consists of a double-acting clutch through which the engine can be connected either to the pump wheel of the torque-converter drive or to the output shaft. It also includes the hydraulic system of the converter proper, and free wheels which allows the car to over-run the engine. The clutch, which has a neutral position, is operated from a double-acting air cylinder through a toggle mechanism. The hydraulic system consists of a centrifugal pump and a three-stage hydraulic turbine which gives a maximum torque multiplication of 5 to 1. The free wheels are of the roller type.

The final double-reduction drive provides a ratio of 3·58 to 1. The gear case is split through the centre of the driving axle and carries torque arms which are fitted to the bogie through universally pivoted links. The input shaft carries an integral spiral bevel gear and is mounted on Timkin roller bearings. These bearings are carried in a steel housing which is secured to the front of the box. The input pinion is maintained in constant mesh with two crown wheels which rotate in opposite directions. They are mounted in roller journals and ball thrust bearings. Internal teeth are cut in these crown wheels, each of which carries a rolling bearing. A spur pinion mounted on this bearing slides axially so as to mesh with the internal teeth of either of the bevel crown wheels, thus providing the required direction of rotation of the axle. The spur pinion is in constant mesh with a spur wheel which is pressed on the driving axle. The sliding spur pinion is controlled by a double-acting air cylinder, the air supply to which is cut off by two three-contact switches. These switches also enable a visual indication to be given to the driver that the gear is in full mesh. Lubrication is effected by "splash" as well as by a gear pump.

CONTROL EQUIPMENT

The control equipment, which has been developed jointly by Leyland Motors, Limited and Walters Brothers, Wigan, is electrically-operated from two 24-volt batteries. It consists of switches on a table in the driving cab, which actuate magnetic valves throughout the train. Four engine speeds, in addition to the idling speed, are available and are adjusted by air cylinders. Four of these cylinders are built into a unit in which a "dead man's" device is incorporated. All the engines return to idling speed when it is released. The clutches are also automatically returned to neutral and the brakes automatically applied.

The clutch control has four positions: "handle off," "neutral," "convertor drive" and "direct drive." The engines can only be started, or the direction of the train changed, when the clutch is in the neutral position. It is controlled by air cylinder on the torque converter to which air is admitted through two magnetic valves. Two over-running free wheels are provided one for the converter and one for the unit drive, in order that the speed of the train may exceed that of the engine when necessary.

The direction control has two positions: forward and backward. It consists of air-actuated pistons which are mounted in cylinders on the housings of the first drives and operate sliding pinions. The compressed air supply is controlled by two electro-pneumatic valves, which are put out of action when the spur pinion on the lay shaft is engaged with the internal teeth. The switches used for this purpose also light lamps to show the driver that the sliding pinions are in the correct position for the desired direction of travel. In the event of a "forward and reverse" sliding pinion creeping out of gear, air is automatically applied to restore it to the correct position. If, however, a fault occurs in the reversing mechanism the drive is arranged so that it can be set manually in the neutral position.

PROVISION OF SAFEGUARDS

Safeguards are provided so that an engine is automatically stopped and its clutch returned to its neutral position if the oil pressure or water level fall below pre-determined figures. These conditions are indicated by a lamp on the control panel and the engine cannot be re-engaged until the fault has been rectified. Operation can, however, be continued with the remaining engines.

Current for starting and the other controls in each coach is drawn from a local battery, but that for energising the relay is supplied from one of the batteries in the coach occupied by the driver. The control circuits in adjacent coaches are connected by multicore cables and jumpers.

The driver's instrument panel also carries a "start" button and a "stop" button as well as a "stop" indicator light for each of eight engines together with revolution counters, speedometers and pressure and vacuum gauges. All the control circuits are supplied through a switch on the table, movement of which selects the battery and locks out the corresponding switches in the other compartments. During shunting the "dead man's" device can be neutralised by pressing a button.

One of the two-car Diesel units which are being built by British Railways to give an improved service on lines where traffic is light.

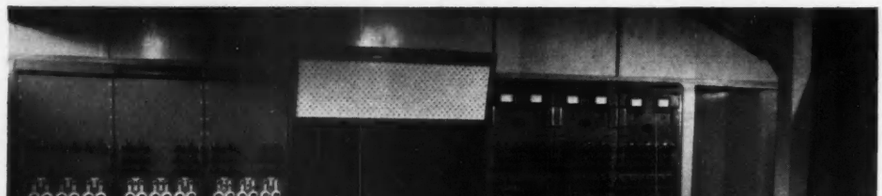


Fig. 1 The analyser as at present built. The network elements are on each side of the plug board. On the right of the control desk is the master oscillator. Three more racks of network elements and plug boards are to be added and also a control desk for transient studies.

VERSATILE NETWORK ANALYSER

COVERS VARIABLE-FREQUENCY, TRANSIENT AND STEADY-STATE PROBLEMS

Some time ago, the British Electrical and Allied Industries Research Association, Leatherhead, Surrey, decided to build a network analyser to be available to the electrical industry for routine and research problems. One quarter has been completed and was demonstrated recently at their Perivale laboratories. An official report* has now been published which describes the equipment in some detail.

The Association decided that, in view of their special position, any apparatus built by them should supplement rather than duplicate others already in existence. This implied that the equipment should have greater range and higher accuracy but, although more versatile, need not be so well adapted for those classes of problems which could be solved on existing analysers. Consideration was given during design to the fact that the network elements can, in principle, be used in three ways. The first is for the study of the behaviour of networks in the steady state at or near a single frequency, the purpose for which the commercial analysers are specifically intended. The second is to study the behaviour of electrical networks in a transient state. Because of limitations of performance of the elements, commercial analysers are normally not suitable for this requirement, which is met by smaller, specialised equipments. The third purpose is for the study of the frequency response of networks. Facilities for this have, so far as is known, not hitherto been incorporated in conventional network analysers.

Substantial economy seemed possible if all these requirements could be satisfied in a single set of elements and interconnections, used in conjunction with two types of generating and measuring equipment, for the steady-state and transient-state studies, respectively. A survey showed that components incorporating techniques and materials now standard in the telecommunications industry could form network elements satisfactory for all purposes. Further, a considerable reduction of cost and bulk would be achieved if the operating power level and the frequency range of the analyser were within the range for audio-frequency telecommunication, since standard telecommunication components would then be satisfactory. This would necessarily call for rather sensitive and complicated measuring equipment, but it was estimated that there was an optimum level at which there was a considerable net gain; also, only inexpensive components would have to be added should any future extension be required.

CHOICE OF PARAMETERS

These requirements led the Association to choose the following base parameters for the analyser:

Impedance, 100 ohms (10 milli-henrys and 1 microfarad).

Power, 2·5 milliwatts (500 millivolts and 5 milliamperes).

Frequency, 1·592 kilocycles ($\omega = 10^4$ radians per second).

Frequency range from 0·1 to 10·0 times base frequency.

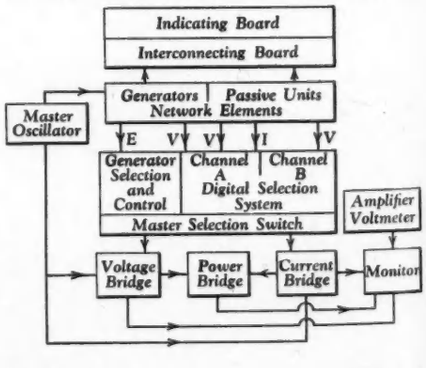
The equipment now in operation is shown in Fig. 1. On each side of the plug board are racks containing the network elements, the top units on the right-hand wing being the three slave generators. The control desk for steady-state investigations is in the foreground, and to the right of it is the cabinet containing the three-phase master oscillator and the electronic metering units. At the top of the plug board is the indicating panel where lights show how the elements are connected. In the centre of the control desk are the dials showing the phase angles of the current and voltage being measured with reference to one phase of the master oscillator, and these are flanked by dials showing the amplitudes as a percentage of the base values. Outside these again are the selector panels by which the point of the network to be metered can be chosen. Selection is by push buttons using a three-figure code number. At the extreme left are three oscilloscopes for monitoring the operating circuits, with their selector switches below them, while on the extreme right is a direct measuring voltmeter for the purposes of making quick checks and for monitoring the voltage across one unit while adjustments are made to others. The push-buttons for selecting the generators are in a row along the bottom.

NETWORK ELEMENTS

A block diagram of the complete analyser as arranged for steady-state investigations is given in Fig. 2. The active network elements or " generators " are of conventional design and the three so far built act as steady-state power sources. They are actually adjustable amplifiers with independent phase and amplitude controls in each. The three-phase output from the master oscillator is fed to a Magslip phase shifter. The single-phase output from this is amplified and measured on a potentiometer and finally emerges from an output amplifier with the low impedance of 0·3 ohm. Adjustable reactances and power and voltage monitors may be inserted in order to reduce the time required to achieve the initial balance in load flow studies. Generators to be constructed in the future will incorporate self-adjusting circuits aimed at embodying the characteristics of actual machines.

The passive network elements consist of two-terminal elements such as decade impedances or simple series or parallel arrangements of these, and also of three- and four-terminal elements such as π-networks and transformers, together with some electronic amplifiers. The terminals of the elements are brought out to a terminal board at the back of the plug board and connected to flexible leads for making the interconnections. Colour identification is used, the three- and four-terminal units being treated as pairs of two-terminal units. Each unit has four terminals for metering purposes: two for voltage and two for current. The latter are the potential terminals of a 20-milli-ohm shunt which is connected in the red lead of each unit.

Types of network elements already installed include high and low impedances, high and low susceptances, steady-state generators, coarse and fine auto-transformers, mutual transformers, and amplifiers and buffers. Elements for the future sections include, medium impedances and



(2116.A) "ENGINEERING"

Fig. 2 Block diagram of the equipment arranged for steady-state studies. Alternative selection channels allow a wide range of comparisons to be made simultaneously.

* The E.R.A. Network Analyser, March, 1954. Technical Report V/T 122 published by the British Electrical and Allied Industries Research Association, Thorncroft-Manor, Dorking-road, Leatherhead, Surrey.

π-networks. Components used (resistors, capacitors and inductors) are standard commercial items with tolerances and stabilities of (in general) ± 1 per cent. Wafer-type switches with silver-alloy contacts are used both in the network units and in the selector system. All components are small and, apart from the susceptance units, the size is determined by the dials of the decade indicators which must be large enough to be read without risk of error. Covers are fitted over the wafer switches to prevent tarnishing of the contacts.

Special measuring equipment has been built for checking both the components and the complete impedance units. Bridge measurement is used and the equipment is mounted on wheels so that it can be moved to any part of the analyser as required. The accuracy of the elements is in general within 1 per cent. of the nominal setting, or 0·1 per cent. of the base value, so that the dial readings can be used without correction. The purity of the reactive components is better than 1 per cent. at the base frequency.

MEASURING BRIDGES

Owing to the low values of the base parameters, a bridge system was necessary for measuring them to the required accuracy. A block diagram of the system is shown in Fig. 3. The main measuring system consists of three automatic alternating-current potentiometers, operating simultaneously to indicate the potential difference (in amplitude and phase) between the selected points in the network; the current (amplitude and phase) through the selected unit; and the products of voltage, current and relative phase angle to give the active and reactive loads.

As mentioned earlier, the reference signal for the bridge measurements originates from the three-phase master-oscillator which excites the generators. From the diagram, it will be seen that measurement is made by comparing the selected signal with the reference signal derived from a potentiometer. A servo-system working from an amplified value of the difference adjusts the potentiometer slides till balance is obtained. It has been found necessary to add some feed-back to the servo to prevent hunting at critical balances. The shafts of the potentiometers and Magslip phase-shifters are coupled to the dials on the control desk which show the amplitudes and phase-cycles relative to the reference and also to each other.

The fact that the analyser was required to operate over a 100-to-1 frequency range suggested that, in the interests of simplicity, an analogue method should be used for power measurement. The multiplying operations are performed on a fixed frequency analogue signal using potentiometers and a sine-cosine resolver ganged with the voltage and current bridges. At present, the resolver introduces errors of up to 2 per cent. at low power levels but, by re-arranging the circuit to make this unit operate on a fixed power level, these can be eliminated and the accuracy will then be governed by the linearity of the potentiometers which is to within about 0·1 per cent. Although somewhat slower than direct measurement, the bridge method gives greater accuracy owing to the increased scale length (20 in.) possible and the corresponding ease of reading. The phase angle of readings taken on the direct-measuring voltmeter can be indicated on one of the cathode-ray tubes. The main purpose of the latter, however, is the monitoring of the measuring system for adjustment and indication of faults. An absolute accuracy to within 1 per cent. and 1 deg. has been achieved in the system.

TWO-CHANNEL SELECTION

The selectors are banks of solenoid-operated wafer-switches chosen according to a three-figure code by push-buttons on the control desk. There are two independent channels of selection, one of which has both voltage and current leads and is normally used with the bridge equipment, while the other has voltage leads only and is generally used with the amplifier voltmeter. In addition, each channel has its own potential lead which may be plugged in at any point in the network; usually it is on the neutral bar. Thus there are three voltage terminals available in each channel and a master selection switch makes several arrangements possible. This enables mutual effects to be studied by observing two units simultaneously and also the products of two complex quantities to be obtained. A separate single channel has been provided for the generators, and the output of these, both in phase and amplitude, can be controlled from the desk. In addition, the generators have controls directly mounted on their panels. With these channel systems, it is possible to observe on a unit the effect of changing the generator input. As stated in the opening paragraph, only one quarter of the analyser has yet been built. Three more sets of network elements and plug boards are to be constructed and also the control desk for transient studies. Work on these is proceeding rapidly, and they will include the results of the experience gained from the existing portion. The equipment is intended for use primarily on work within the general framework of the Association's programmes and then for research work by members. Work for outside bodies will also be considered. The range of problems which can be dealt with by the existing equipment includes power systems, transients and frequency response in networks and the analysis of feedback amplifiers and servo-systems.

* * *

DIESEL-ENGINED BUSES TO REPLACE TROLLEYBUSES

Diesel buses having aluminium bodies are to replace the electric trolleybuses now being used on 64 services in the London area, the London Transport Executive announce. The change is expected to take place in about three years time. The decision was made with the approval of the British Transport Commission after consultation with the Minister of Transport.

Most of the trolleybuses will have been in service for 21 years by that time and will then be considered to have completed their useful service. Each vehicle will have run nearly 900,000 miles and thereafter maintenance would be uneconomical.

The new buses will seat 64 passengers, compared with 70 in the trolleybus, will be 8 ft. wide and 27 ft. long. They will therefore be 6 in. wider and 1 ft. longer than most of the present London buses.

The weight saved by using aluminium and the increased length will allow eight more passengers than in the present London RT bus to be carried. The suspension and transmission system will be improved to increase the passengers' comfort. The changeover has been influenced by the fact that the internal-combustion engined vehicle can be manœuvred more freely in congested traffic and be moved to other areas as the population changes.

Many of the power stations now supplying current for the trolleybuses will become available for other London Transport needs, mainly on the underground railway.

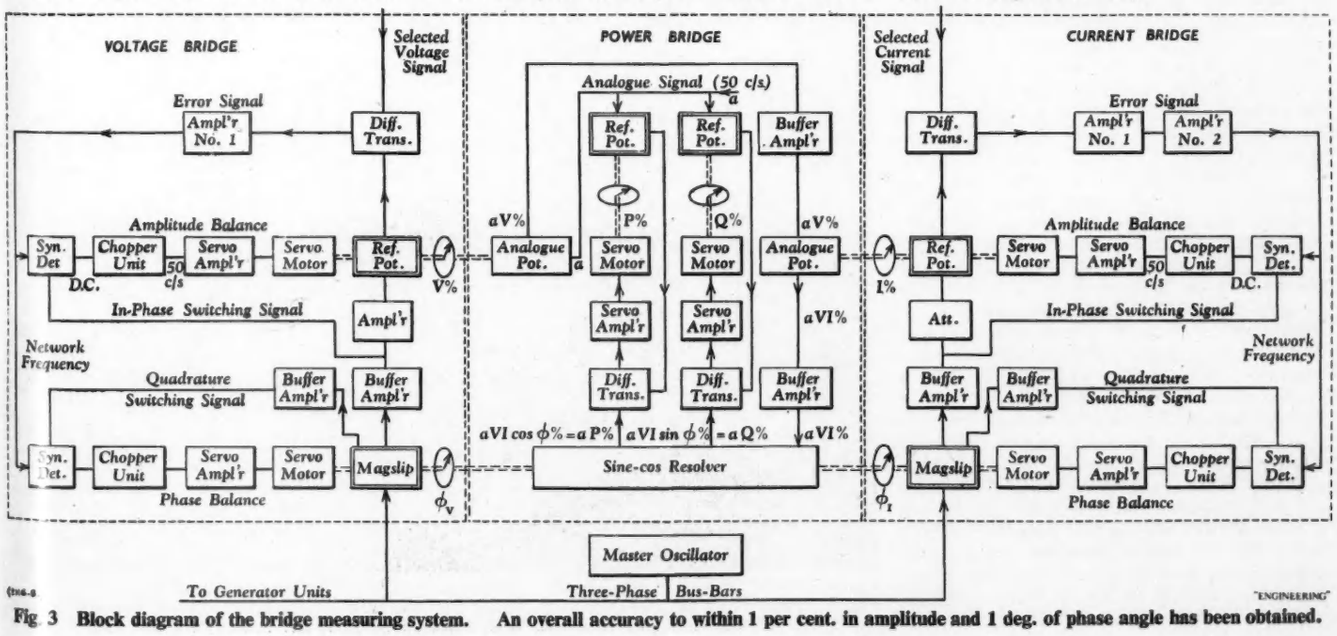


Fig 3 Block diagram of the bridge measuring system. An overall accuracy to within 1 per cent. in amplitude and 1 deg. of phase angle has been obtained.

RE-EQUIPMENT OF A LONDON TRANSPORT SUBSTATION

MERCURY RECTIFIERS REPLACE 50-YEAR-OLD ROTARY CONVERTERS

The re-equipment of the Bond-street substation of London Transport with mercury-arc rectifiers, in place of the rotary converters some of which have been in use for over 50 years, marks the first stage in a scheme of modernisation on the system, which has been necessitated by the increased traffic. Since 1928, moreover, these old machines have been running at a higher speed than that for which they were originally designed, owing to the frequency of supply having been increased from 25 to 33⅓ cycles. The fact that static plant can be operated by remote supervisory control is another point in its favour.

The work of conversion, which was begun early in 1953 and is now virtually completed, was complicated by the fact that the substation is situated in a heavily built-up area, where there is no room for expansion and where noise and fire risk were important factors. The only access to the street was through the station booking hall, so that the size and weight of the equipment that could be handled through that entrance was restricted. Finally, the need to maintain the power supply while the change-over was taking place necessitated careful planning and a close attention to detail upon which all concerned are to be congratulated. The change-over was undertaken by the Hackbridge and Hewittic Electric Company, Limited, Hersham, Walton-on-Thames, Surrey, in close collaboration with the chief electrical engineer of London Transport.

THE ORIGINAL LAYOUT

Fig. 1 shows the original rotary converters which, as will be seen, were housed in a long narrow section of the station in which the crane height was restricted. To maintain the output during reconstruction, one of the end walls was taken down and a small annexe to house the temporary high-tension alternating-current switchgear was built on adjacent land. As access to this annexe was possible from an adjoining yard all the heavy machinery, some of which weighed 30 tons, was handled through it, although some of the plant was taken through the passenger station after normal traffic hours.

Inside the substation the first step was to install a new lighting transformer in place of the existing 100-kVA unit and thus to provide handling space. A 500-kW rectifier was next installed temporarily in the space available between two of the rotary-converter transformers, one of which was then dismantled. This enabled a second 500-kW rectifier to be erected. The capacity of the new equipment was increased by the addition of two bulbs in each unit, so as to cover the transitional period when the overall capacity of the substation was reduced by the disconnection of a rotary converter.

Meanwhile, the first rotary converter and its concrete foundation were being removed, the floor re-levelled and the next rectifier placed in its permanent position. To overcome the difficulty of removing the remaining machines the rectifiers were partially dismantled by the removal of three bulbs and the associated cooling fans. The fact that the rectifiers were designed for this to be possible enabled the 11-ton armatures and yokes of the rotary converters to be withdrawn with a minimum of clearance between the old and new equipment. This will be clear from Fig. 2, which shows the rectifier cubicles partially dismantled while the last rotary-converter armature was being removed.

ACCURATE PLANNING AND TIMING

At first it was thought that these change-overs would have to be effected during the night when the line is shut down. By accurate planning and timing of the operations, however, they were achieved during the morning off-peak periods. The most difficult situation was reached when, in order to withdraw the fourth rotary converter, three rectifiers had to be dismantled. To do this the armature was held in readiness on the crane beforehand and by the time it had been loaded on to the waiting vehicle the first rectifier had resumed service, while the other two were re-assembled and put on load within four hours. The rectifier, which as mentioned above had been temporarily installed and equipped with four additional bulbs, carried the load during the whole of this period. It was subsequently transferred to its permanent position, thus successfully completing the first stage of the conversion. A view of the substation with the rectifiers in their permanent positions is given in Fig. 3.

The second stage of the conversion consisted of re-equipping the switchgear section. This involved the installation of a bank of 11-kV oil circuit-breakers, two direct-current switchboards, one embodying truck-type high-speed circuit-breakers and control panels on the positive bus-bar and the other withdrawable contactors and panels on the negative side. In addition, auxiliary transformers and switchgear for supplying the lighting and signal circuits and finally supervisory control gear was installed.

POWER SUPPLY

The substation is supplied with power from Notting Hill Gate through two 11-kV cables, which replace the original 5·5-kV feeders. These cables terminate on a high-tension switchboard, consisting of duplicate bus-bars and seven oil circuit-breakers each with a rupturing capacity of 350 MVA. These circuit-breakers control the incoming feeders and the connections to the four rectifier transformers and the lighting transformer. Each rectifier circuit-breaker is electrically interlocked with its corresponding direct-current breaker, so that, in the event of an internal fault, the rectifier itself will be isolated from the supply. This 11-kV switchgear was manufactured by Switchgear and Cowans, Limited, Manchester. Its installation necessitated the demolition of a gallery on which the old 5·5-kV switchgear stood.

TRANSFORMER DESIGN

The rectifier transformers, which were supplied by the Hackbridge and Hewittic Electric Company, are of the three/six phase totally-enclosed dry-air insulated type. There is no oil, and cooling is effected by a fan-cooled air-to-air heat exchanger. The air from the transformer case is circulated through this exchanger by a second fan and is continuously directed by baffles through not only the core and windings, but through the adjoining compartment, which houses the auxiliary transformer, interphase transformer

Fig. 1 900-kW rotary converters in the Bond-street substation of London Transport. These 50-year-old machines have now been replaced by 1,000-kW mercury-arc rectifiers.

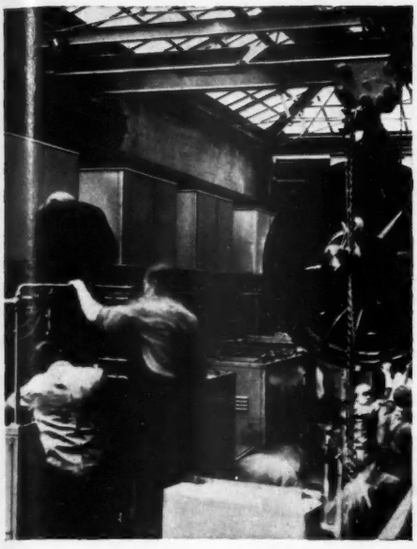


Fig. 2 A rotary converter armature in course of removal. The rectifier cubicles, shown on the left, have been partially dismantled to allow this to be done.

and fan choke. The phase angles of each pair of transformer primaries are displaced, one 15 deg. forward and one 15 deg. backward, thus resulting in the 12-phase operation of each 1,000-kW set.

It may be mentioned that closed-air circuit transformers of this type were first manufactured by the Hackbridge and Hewittic Electric Company in 1948 and have proved satisfactory in service, especially from the point of view of fire risk.

Owing to the restricted floor space available, the transformers and rectifiers are combined into one unit, as shown in Fig. 3, the transformers and auxiliaries being contained in a base compartment over which are the cradles enclosing the rectifier bulbs. In this way it has been possible to dispense with all interconnecting cabling and to utilise space originally occupied by rotary converters for the new direct-current switchgear and supervisory control equipment.

Each of the four 1,000-kW rectifiers is made up of two 500-kW units, which together occupy about the same floor space as a rotary converter. They contain six three-anode bulbs, which are mounted in two triangular groups. The exciter unit, anode fuses and anode chokes are installed in a separate compartment alongside the main transformer. Each group is cooled by a separate fan which, except for the starting relay, is the only moving part. The rectifiers were commissioned on the 33⅓ cycle supply, but have been designed so that it will only be necessary to replace the fan motors and to adjust the exciter and anode chokes when the change is made to 50 cycles.

DIRECT-CURRENT SWITCHGEAR

The direct-current side of each 1,000-kW unit is controlled by a circuit-breaker which was temporarily installed alongside the appropriate recitifier until the last rotary converter had been removed. The original direct-current switchboard was then dismantled and the new equipment which was installed in its place was manufactured by Bertram Thomas (Engineers), Limited, Hulme, Manchester, 15.

The positive direct-current circuit-breakers are of the high-speed truck type and are arranged in a bank of ten with a bus-coupler contactor in the centre. They control the four rectifiers, as well as four track feeders and two escalator feeders. Each circuit-breaker is electrically interlocked with its corresponding negative contactor, so that the latter opens directly its circuit breaker is tripped. These contactors are also of the truck type and are arranged to face the circuit-breakers, a passage being left between them to allow for servicing and inspection. All the circuit-breakers are interchangeable and, like the contactors, are closed electrically from a 110-volt battery and tripped by a 50-volt battery. The rectifier circuit-breakers are arranged for reverse tripping and those on the feeders for forward tripping. The switchgear is arranged to enable the tracks eastward of the substation to be separated from those to the west, as experience has shown the desirability of this method of supply.

The whole of the switchgear has been designed for eventual operation by remote supervisory control. Control is, however, at present effected from a central panel from which starting and stopping will be effected and upon which indications and alarms are mounted.

The modernisation of this supply point on the London Transport system has included the replacement of the cables feeding the tracks and escalators. The new cables, which were manufactured by W. T. Glover and Company, Limited, Trafford Park, Manchester, are installed in a disused lift shaft which has permitted segregation and easy access for maintenance. Both the high- and low-tension cables are of the non-bleeding, paper-insulated type and are impregnated with Diatrine compound. There is a vertical drop of 80 ft. between the upper and lower levels.

A similar substation conversion is to be carried out under the same conditions by the Hackbridge and Hewittic Company at Charing Cross Station. This has a present capacity of 9,000 kW and an ultimate capacity of 12,000 kW, so that it is one of the largest on the London Transport system.

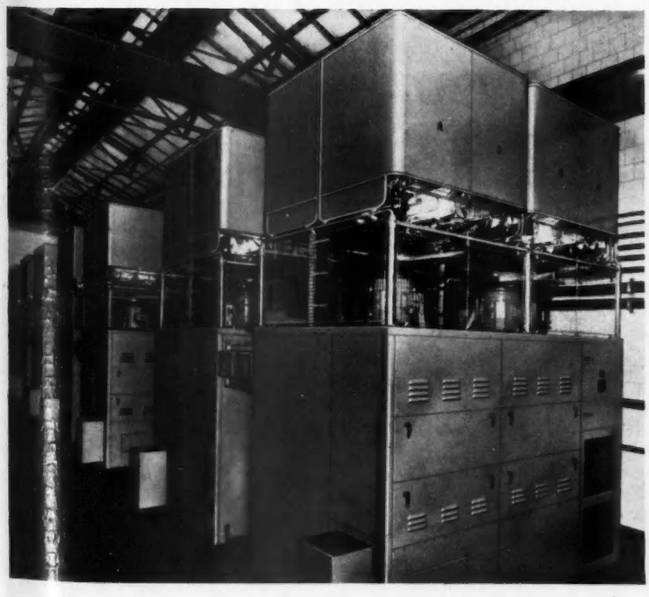


Fig. 3 1,000-kW rectifiers installed in Bond-street substation by the Hackbridge and Hewittic Electric Company, Limited.

* * *

175-WATT POWER PANEL

Suitable for Sound Relay Systems

The General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, have designed a power output panel for general use in sound-equipment installations where high-power amplifiers are required. It can be incorporated in high-quality relay systems to give an output of 100 watts under mainly Class A conditions, or in industrial public address systems where it will provide 175 watts under moderate Class AB2 drive. Up to 24 of these power output panels, operating in the 100-watt condition, can be connected to a driver panel to provide a maximum output of 2,400 watts; alternatively, up to 12 panels, operating in the 175-watt condition, will provide a maximum output of 2,100 watts. Such arrangements are suitable for large installations with either pooled or multi-channel outputs and also for installations where extensions to the original system may be needed in the future.

CIRCUIT DESCRIPTION

The output stage comprises two Osram DA100 valves operating in a push-pull circuit and mounted on the front of the panel. The input terminals are connected directly to the grids which are tied to the chassis by resistors. The output transformer is provided with an electrostatic screen between the primary and secondary windings, the latter being divided into two balanced sections so that series or parallel connection is possible and a wide range of output voltages and impedance can be obtained. The high-tension supply is provided by four bridge-connected directly-heated vacuum valve rectifiers, with choke input to the reservoir condenser. The choke is fitted with a resistor/capacitor limiting network.

The high-tension and low-tension supplies are provided by separate mains transformers with independent switching. This allows for stand-by running on heaters only, with instant operation facilities for remote control equipment if desired. A meter is provided, with an associated switching key, to indicate the cathode current of the two output valves either singly or together.

The equipment operates from an alternating-current power supply of 200-250 volts at 50-100 cycles. Stand-by power consumption (low-tension only) is 86 VA, while full running consumption is 567 VA (at maximum output).

The frequency response is maintained within $\pm$ 2*db* throughout the range 50-10,000 cycles. With a 100-watt power output under Class A conditions, total harmonic distortion is 3 per cent. With a 175-watt power output and moderate Class AB2 drive, the total harmonic distortion is 6 per cent. The equipment weighs 96 lb. and measures 15¾ in. high by 19 in. wide.

The Dusgard unit, in which air currents drawn through the slots in the faceplate collect the dangerous micro-dust particles and protect the operator's breathing zone.

CONTROLLING GRINDING DUST

To protect operators of pedestal grinders from the dangerous micro-dust which is carried in the airstream produced by the peripheral speed of the grinding wheel, a new system of external dust control has been developed by the British Cast Iron Research Association, and is now being manufactured, under the name Dusgard, by Air Control Installations, Limited, Ruislip, Middlesex. The new technique has proved on test to be highly effective; dust counts were made by the thermal precipitation method, and after incineration samples of air at the breathing zone were found to have dust counts not above that of the general atmosphere.

The essential feature of external dust control is the use of currents of fast-moving air to form an invisible "curtain" to contain and collect the micro-dust particles which are dangerous to the lung tissue. As may be seen in the accompanying illustration, the mild-steel faceplate of the Dusgard unit has three slots which are connected to an exhaust manifold at the back of the plate, from which two side screens extend back to the sides of the standard wheel guard.

In action, the horizontal slot across the top of the wheel generates a horizontal air curtain protecting the operator's breathing zone. The two vertical slots generate current on either side of the wheel, collecting side "splash" and reducing pollution of the general environment.

Suction is also required on the bottom box or hood to remove the heavy particles thrown directly into the hopper. To assist the down-flow of these heavy particles, a specially-designed slotted work rest is provided.

When the Dusgard equipment is to be applied to a complete new system, both the Dusgard unit and the bottom hood would be connected to a common duct system, exhausted by a fan to a collector. In applying Dusgard to an existing installation where the existing hood exhaust is functioning efficiently, the Dusgard unit can be connected to a separate duct system, exhausted by a centrifugal fan, without altering the conventional hood exhaust.

The discharge from the collector or fan of a Dusgard system must be considered as dangerous to health and must be carried well above roof level. Where the ducting passes through buildings the joints must be properly sealed. All-welded ducts with joints flanged and fitted with gaskets should be used on the discharge side of the fan.

Dusgard is made in standard sizes to suit most wheel sizes and makes of stand grinder. Where the wheels are narrower than standard, closing strips must be fitted to the Dusgard unit. Although developed primarily for heavy pedestal grinders, the technique can be applied to many other dust problems, such as those encountered with buffing wheels, masonry and tile saws, linishers, etc.

* * *

MOBILE SOIL-BORING MACHINE

18-*In. Diameter Holes Cut to a Depth of* 15 *Ft.*

A soil boring machine, which is based upon a design developed by the Road Research Laboratory, Harmondsworth, Middlesex, is being made by Le Grand, Sutcliff and Gell, Limited, Southall, Middlesex. A description of the original machine was given in ENGINEERING, vol. 174, page 805 (1952). The soil borer shown in the illustration on this page is one of two machines demonstrated at Priors Farm, Ruislip, on April 29, for the benefit of contractors and members of the Press. In the illustration the auger is raised to throw off the soil.

Both machines were mounted on a trailer chassis. Alternatively they can be mounted on the rear of any medium-weight lorry. A Petters type AVA series II Diesel engine, developing 8-h.p. at 1,200 r.p.m., provides the power for rotation and feeding of the auger, and raising and lowering the mast. Most of the changes in the original design have not affected the general principles, but were made purely to facilitate production on a commercial basis. One of the original control levers for stopping the feed has been incorporated with the Kelly-bar feed-control lever.

This soil boring machine can be operated by one man and can bore holes at the rate of 1 ft. per minute.

During the demonstration three typical applications were shown: setting up with jacks beneath the rear of the trailer and boring a 15-ft. deep hole of 18-in. diameter; drilling a similar hole at an angle of 45 deg. to the ground surface; and drilling three short pile holes in a line without placing jacks beneath the trailer. The normal speed of rotation of the boring tool is 80 to 100 r.p.m. and the average boring rate 1 ft. per min. The boring rate is said to have been doubled on one particular site without causing any trouble. The bar and tool can be raised and lowered at 3 ft. per sec. and the time required for erecting the mast from the sloping position in which it is transported is one minute. A particular feature of this machine is the ease with which the controls can be handled by one man.

In operation the tool bores into the ground about six inches per operational cycle. It is then raised and spun, releasing the soil by centrifugal action. A safety device is incorporated in the engine shaft so that the drive can slip if any large object is struck by the rotating tool during boring.

ELECTRODES FOR ARGON-ARC WELDING

An electrode which shows greater resistance to contamination in the argon-arc welding process than the pure tungsten and thoriated-tungsten electrodes hitherto generally used has been developed by Murex Welding Processes Ltd., Hertford-road, Waltham Cross, Hertfordshire. It is the zirconiated-tungsten electrode.

It will be appreciated that electrodes used in argon-arc welding, in theory, are non-consumable, that is, they do not contribute to the weld metal. In practice, however, considerable wastage occurs mainly owing to the regrinding which is necessary to keep the electrode tip free from contamination. During welding, contamination of the point occurs by particles of metal or oxide thrown up from the molten pool of the weld. Obviously, the electrode can also be directly contaminated by touching the molten pool or by contact with the filler wire. In the case of a pure tungsten rod, contamination means immediate regrinding. Thoriated-tungsten electrodes, which incorporate thoria to increase their emission, have certain advantages over the pure-tungsten type. It is easier to maintain a suitable welding point when using thoriated-tungsten electrodes because they offer greater resistance to contamination than pure tungsten and they also enable the arc to be re-struck more readily. Direct contamination either by contact with the molten pool or filler wire, however, necessitates regrinding.

When using the zirconiated-tungsten electrode on the other hand, even if it be deliberately allowed to touch the molten pool and the filler wire during welding, the point of the electrode is not "wetted" and no globule forms on the tip as in the case of pure-tungsten and thoriated-tungsten electrodes. The makers emphasise that it is possible to continue welding with zirconiated electrodes when, in similar circumstances, pure-tungsten and thoriated-tungsten electrodes would require immediate re-grinding.

Labour Notes

NEW WAGE CLAIMS SUGGESTED

In spite of the fact that the employers' offer of higher wages for operatives in the engineering industry was accepted by the Amalgamated Engineering Union and other organisations affiliated to the Confederation of Shipbuilding and Engineering Unions as recently as April 8, discussions on the advisability of making further wage demands were due to take place at the annual conference of the union's national committee at Blackpool, which opened last Monday.

There were, in all, some 40 resolutions on the agenda in favour of fresh wage claims being presented. The proposals ranged from renewed demands for a 15 per cent. increase to requests for the granting of a minimum wage of £8 a week for unskilled employees and of £9 10*s.* a week for skilled men. These rates would involve increases of about £1 10*s.* and £2 a week, respectively. Other motions advocated that demands should be made for "substantial" wage increases. Some resolutions proposed the general condemnation of all forms of wage restraint.

Although it is true that many of these resolutions were tabled by branches of the union before the recent wage settlement was agreed to between the Confederation and the Engineering and Allied Employers' National Federation, there seems no reason to assume that the branches' demands would have been less had that agreement been already concluded.

It may be recalled that the negotiations which ended on April 8 had the effect of raising the minimum wages of skilled male engineering operatives by 8*s.* 6*d.* a week, those of semi-skilled employees by 7*s.* 6*d.* a week, and those of labourers by 6*s.* 6*d.* a week. These advances amounted to increases of approximately 6 per cent. on the men's consolidated time rates.

QUICKER NEGOTIATIONS AND SHORTER HOURS WANTED

An interesting point about the agenda was that proposals for making demands for direct wage increases greatly outnumbered those which advocated that the suggested new wage structure for the industry should be pursued. As on previous occasions, there were requests for the prompter settlement of wage claims and for the establishment of a 40-hour working week.

Several branches of the union expressed their dissatisfaction at the attitude of the general workers' unions affiliated to the Confederation, in respect to the previous wage claim. Particular indignation appears to be felt regarding the lukewarm attitude of these unions at the time of the one-day token strike last December. Motions tabled by these branches urged that greater loyalty should be shown by affiliated unions to majority decisions of the Confederation.

Some motions demanded that the union should withdraw from the Confederation, but others requested that the general unions should be expelled by the Confederation.

FAILURE OF NEGOTIATIONS ON ENGINEERING SALARIES

Discussions on pay increases, between the Engineering and Allied Employers' National Federation and trade unions representing the various grades of salaried employees in the engineering industry, broke down on April 29. The unions had asked for advances based on the ages of the operatives concerned, and their proposals would have resulted in increases graduated between a minimum rise for persons aged 21 and a maximum for those of 25 years of age.

Representatives of the Federation expressed their willingness to grant a flat-rate advance in salaries to the grades in question, but firmly declined to accept the principle of increases varying according to the ages of the recipients. The increase suggested is understood to have been not more than the 8*s.* 6*d.* a week recently granted to skilled manual employees in the industry.

Those affected by the discussions include scientific staffs, planning engineers, calculators, draughtsmen, tracers and clerical employees. One of the unions involved in the discussions, the Association of Engineering and Shipbuilding Draughtsmen, had claimed salary increases varying from 20*s.* a week for men aged 21 to 30*s.* a week for those aged 25 and above.

The unions refused to accept the Federation's proposals and decided to report back to their respective executive councils. It is expected that this action will lead to the claims eventually being submitted to arbitration.

EMPLOYMENT FOR PERSONS OF PENSIONABLE AGE

An encouraging response appears to have come from employers in all parts of the country to the Government's request that employment should be found for elderly workpeople.

Speaking at Kingston-on-Thames on April 29, at a meeting arranged by the Kingston Local Employment Committee, Mr. Harold Watkinson, Parliamentary Secretary to the Ministry of Labour and National Service, said that, within a few weeks of the publication of the White Paper on *The Employment of Older Men and Women* (Cmd. 8963, H.M.S.O., price 2*s.* net), some 60 firms had withdrawn the age limits relating to vacancies on their staffs. These vacancies had already been registered at the local employment exchanges.

During the same period, another 500 firms had notified the Ministry's exchanges of vacancies particularly suitable for elderly persons. Since that time, Mr. Watkinson stated, there had been a steady flow of reports to the Ministry's headquarters of modifications which had been made in the age limits attaching to vacancies throughout the country, and of special schemes which had been inaugurated to promote the employment of older men and women.

With respect to the difficulties which might arise in respect to some firms' pension schemes, Mr. Watkinson said that the Ministry had been in consultation with interested bodies and it was hoped that detailed proposals to deal with that aspect of the matter would be made at an early date.

ELDERLY PEOPLE SHOULD HAVE CHANCE TO WORK

Men aged 65, Mr. Watkinson said, could now expect to live to an average age of 77, and women aged 65 were likely to live to almost 80 years of age. Fifteen years or thereabouts was a long time and it would be a tragedy to condemn unwilling persons to idleness for such a lengthy period.

He asked that a fair chance of employment should be given to all elderly persons who desired to work and were able to do so. Many firms had found that people of pensionable age were, on the whole, unsuitable for work requiring speed or sustained muscular effort, although this statement was far from being true of all elderly men and women.

On the other hand, such persons were especially good at work which required more than ordinary care and attention to detail. A point of particular interest in relation to the older folk was that they were less liable to absenteeism than younger men and women.

Questioned on the problem of the elderly person who wished to return to clerical or administrative work, Mr. Watkinson agreed that there was often no vacancy of that type available for a person of pensionable age. Office employees, however, did not lose caste if they went into some other type of occupation.

Mr. Watkinson concluded by saying that the Government's slogan was "capacity not age" and that everyone should accept its implications.

UNION'S PLEA FOR RETIREMENT AT 65

A very different view on the questions of early retirement and the provision of work for elderly persons is expressed in a report to be presented to National Federation of Professional Workers at their annual conference, which will be held in London and is due to start to-morrow.

Referring to the White Paper on employment for elderly persons, mentioned above, the Federation states that it does not accept the contention that there should be no customary age for retirement. On the contrary, the Federation feels that everyone should have a reasonable expectation of retirement at an age not later than 65.

A retiring age should be laid down by all firms, so that they may be able to recruit newcomers on the basis of their expected wastage. The fixing of a retiring age was also required to allow firms to work out pension schemes to enable their workpeople to receive reasonable pensions on retirement.

The Federation, which has an affiliated membership of well over 500,000 persons, also draws attention to the fact that the retention of employees beyond the usual age of retirement reduces the opportunities of employment for persons in the middle-age groups. This applies with particular force, the Federation contends, in the case of the clerical and professional classes, in respect to which there are special difficulties in the way of finding employment for persons of middle age.

The White Paper is the first report of the National Advisory Committee set up by the Minister of Labour and National Service in February, 1952, to investigate the problem of obtaining work for elderly people.

REDUNDANCY AMONG EMPLOYEES ENGAGED ON COMET AIRCRAFT

Nearly 800 persons employed at the Belfast factory of Messrs. Short Brothers and Harland Limited have been declared to be surplus to the firm's labour requirements, owing to the suspension of work on Comet airliners, and have been given a week's notice, due to expire to-day. A total of about 1,600 men were engaged on these aircraft but many of them will be found employment on other contracts.

It was announced last Friday that officials of the Confederation of Shipbuilding and Engineering Unions and shop stewards from the factory would meet the Northern Ireland Minister of Commerce, Lord Glentoran, to discuss the situation. The trade-union officials were expected to ask the Minister to give Government aid to the firm to prevent dismissals.

In reply to a parliamentary question in the House of Commons last Monday, Mr. Duncan Sandys, the Minister of Supply, stated that Messrs. Short Brothers had managed to provide alternative employment for about half the men engaged on the Comet airliners by bringing forward work on other orders and by discontinuing overtime work as far as possible.

SLOTTED ANGLES FOR FABRICATED FRAMES

Dexion, Limited, 189 Regent-street, London, W.1, have made an addition to their range of slotted angles in steel and aluminium alloy. These angles are intended for use in building up large and small frames for a variety of purposes by bolting appropriate lengths together. The new angle, which is made in 10 ft. lengths, measures 2¼ in. by 1½ in., compared with 3 in. by 1½ in. in the older type. While the 3-in. side of the original angle was pierced with two rows of slots, 2⅜ in. long, in the new pattern there is one row of 2⅜ in. slots and one row of shorter ⅜ in. slots in the 2¼ in. side. Between the longer slots are round holes and transverse slots. The 1½ in. side of the angle contains only one row of ⅜ in. slots. The slots in one row are spaced alternately with that in the other.

It is claimed for the new arrangement that it is stronger than the original, in spite of its smaller size, owing to the elimination of the double row of slots. The holes allow a three-section corner which has a positive bearing in all directions to be constructed. The replacement of slots by holes for fixing the bolts minimises any tendency to slip. Moreover, they enable triangulated structures to be built up. The transverse slots allow lengths of angle to be spliced to extend an upright, the two lengths to be joined being placed end to end and a short length of angle bolted in position through the transverse slots in each section.

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AERO-ENGINE TEST PLANT IN CANADA

A new test house, capable of handling the largest types of propeller turbines and piston engines, was officially opened at the Montreal North plant of Bristol Aeroplane Engines (Eastern), Limited, a subsidiary of the Bristol Aeroplane Company of Canada, Limited, in March.

The plant has been designed to cut noise to a minimum, and engines which could normally be heard for many miles are barely audible 100 yards from the test house. The test cell itself is a structure 25 ft. tall by 60 ft. long and 30 ft. wide and its sound-proofing equipment incorporates 1,780 sound absorbers.

The test house is planned for five-hour to eight-hour tests of 80 engines a month. Careful design has made use of every practical safety precaution evolved over many years' experience of the operation of engine test plant.

The new "Bristol" test-bed will handle the Curtiss-Wright engines being supplied to Trans-Canada Airlines for their Super-Constellation airliners and is also capable of testing the engines which will power the maritime Britannias to be built by Canadair Limited in Montreal.

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HYDRO-ELECTRIC SCHEMES IN SCOTLAND

The Secretary of State for Scotland has confirmed a scheme of the North of Scotland Hydro-Electric Board for developing the water power resources of the River Orrin, the Allt na Fainich, the Allt Goibhre, the Allt na Criche and their tributaries in Ross-shire. The scheme provides for the creation of a new loch in Glen Orrin, five miles upstream from the Orrin Falls, by the construction of a dam across the River Orrin. Water will be taken from this loch through a tunnel to a generating station with an installed capacity of 18,000 kW. This station will be erected near Achonokie in Strathconon on the southern shore of the loch which is at present being created at Torr Achilty as part of the Board's Glascarnoch, Luichart and Torr Achilty scheme. The water discharged from the Achonokie plant will also pass through the Torr Achilty station.

LAUNCHES AND TRIAL TRIPS

S.S. "GREENBATT."—Single-screw vessel for the carriage of timber and other cargoes, built by S. P. Austin & Son, Ltd., Sunderland, for the Newbigin Steam Shipping Co., Ltd., Newcastle-upon-Tyne. Main dimensions: 252 ft. 6 in. by 40 ft. 3 in. by 18 ft. 5 in.; deadweight capacity, about 2,500 tons on a mean summer draught of 17 ft. Direct-acting triple-expansion steam engine of reheat design, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Steam supplied by two oil-burning forced-draught boilers. Service speed, 9½ knots. Launch, March 31.

S.S. "ROMANIC."—Single-screw cargo vessel, built and engined by Smith's Dock Co., Ltd., South Bank-on-Tees, for the Bolton Steam Shipping Co., Ltd., London, E.C.3. Main dimensions: 450 ft. 8 in. overall by 59 ft. by 38 ft. 3 in. to upper deck; deadweight capacity, 10,000 tons on a draught of about 26 ft. 3 in. Triple-expansion steam engine working in conjunction with a Bauer-Wach turbine, developing 3,000 i.h.p. in continuous service. Steam supplied by three multitubular boilers. Launch, April 6.

M.S. "LONDON PRESTIGE."—Single-screw oil tanker built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for the London and Overseas Freighters Ltd., London, W.1. Main dimensions: 560 ft. between perpendiculars by 80 ft. by 42 ft. 3 in. to upper deck; deadweight capacity, 24,600 tons on a summer draught of 32 ft. 3½ in.; oil-carrying capacity, 23,533 tons. N.E.M.-Doxford six-cylinder two-stroke single-acting opposed-piston oil engine, developing 6,800 b.h.p. at 119 r.p.m. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Speed, 14 knots. Trial trip, April 20.

M.S. "DUNDEE."—Single-screw cargo vessel, with accommodation for six passengers, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for the Dundee, Perth and London Shipping Co., Ltd., Dundee, for service on the St. Lawrence River and Great Lakes, Canada. Main dimensions: 251 ft. between perpendiculars by 43 ft. by 29 ft. 2 in. to shelter deck; deadweight capacity, about 2,900 tons on a draught of 18 ft. 11 in.; gross tonnage, 1,781. Nine-cylinder Diesel engine, developing 1,640 b.h.p., constructed by British Polar Engines, Ltd., Glasgow. Speed, 11 knots. Trial trip, April 23.

NOTICES OF MEETINGS

Institute of Fuel

BIRMINGHAM
Annual General Meeting. Midland Section. James Watt Memorial Institute, Great Charles-street, Birmingham, 3. Thurs., May 27, 6 p.m.

Institute of Marine Engineers

LONDON
"The Free-Piston Gas-Generator Turbine as a Power Plant for Ship Propulsion," by F. A. I. Muntz and Robert Huber. Tues., May 11, 5.30 p.m.
Films: "Power for Ships" and "Diesel Power on the River Thames." Junior Section. Mon., May 17, 6.30 p.m.

Institute of Petroleum

LONDON
"Medical Services in the Petroleum Industry." Symposium. Papers presented by S. D. McClean and F. L. Webster. Wed., May 19, 5.30 p.m.

Institution of Chemical Engineers

BIRMINGHAM
"Application of Plastics in Chemical Engineering." Discussion. Midlands Graduates' and Students' Section. Chemical Engineering Department, Birmingham University, Edgbaston, Birmingham. Wed., May 26, 11 a.m.

Institution of Civil Engineers

LONDON
"Wear of Steel Rails: A Review of the Factors Involved," by J. Dearden. Railway Engineering Division. Tues., May 11, 5.30 p.m.
"Design and Construction of the Superstructure of the Marshal Carmona Bridge at Vila Franca de Xvia, Portugal," by T. J. Upstone and W. Cardno. Structural and Building Engineering Division. Tues., May 18, 5.30 p.m.
BIRMINGHAM
Annual General Meeting. Midlands Association. James Watt Memorial Institute, Great Charles-street, Birmingham, 3. Thurs., May 13, 6 p.m.
MANCHESTER
Annual General Meeting and Film Evening. North-Western Association. Engineers' Club, Albert-square, Manchester. Thurs., May 13, 6.30 p.m.

Institution of Electrical Engineers

LONDON
"Fuel Supplies of the Future," by E. F. Schumacher. Utilization Section. Thurs., May 13, 5.30 p.m.
Questions Night. Education Discussion Circle. Tues, May 18, 6 p.m.
Annual General Meeting of the Institution. Corporate Members and Associates only. Thurs., May 20, 5.30 p.m.
Annual General Meeting and Film Evening. London Students' Section. Mon., May 17, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
"Rapid Starting Technique: Some Significant Tests at Poole Power Station," by J. S. Hall and A. F. Brittin. Steam Group Meeting. Fri., May 14, 5.30 p.m.

Institution of Production Engineers

BIRMINGHAM
"Work Study and the Production Engineer," by R. Guthrie. Birmingham Graduate Section. James Watt Memorial Institute, Great Charles-street, Birmingham, 3. Tues., May 11, 7 p.m.
SHREWSBURY
"Cutting Tools: Their Development and Application," by W. Castledine. Shrewsbury Section. Shrewsbury Technical College, Shrewsbury. Wed., May 26, 7.30 p.m.
STOKE-ON-TRENT
"Metal Spraying," by H. J. Plaster (with film). Stoke-on-Trent Section. Building Department, North Staffordshire Technical College, Cauldon-place, Shelton, Stoke-on-Trent. Fri., May 21, 7.30 p.m.
WOLVERHAMPTON
"The Metallurgist's Place in Production Engineering," by E. R. Gadd. Wolverhampton Graduate Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Thurs, May 20, 7.30 p.m.

Institution of Structural Engineers

CARDIFF
Annual General Meeting. Wales and Monmouthshire Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., May 11, 6.30 p.m.
PLYMOUTH
Annual General Meeting. South-Western Counties Branch. Duke of Cornwall Hotel, Plymouth. Fri., May 21, 7 p.m.

Newcomen Society

LONDON
"The New Era in the History of Technology," by Dr. Charles Singer. First Dickinson Memorial Lecture. Science Museum, Exhibition-road, South Kensington, S.W.7. Wed., May 12, 6 p.m.

Royal Aeronautical Society

LONDON
"The Use of Materials in the Plastics Range," by H. L. Cox. Section Lecture. Thurs., May 13, 7 p.m.
"The Choice of Power Units for Civil Aeroplanes," by Dr. A. E. Russell. 42nd Wilbur Wright Memorial Lecture. Royal Institution, Albemarle-street, W.1. Thurs., May 20, 6 p.m.

Royal Meteorological Society

LONDON
"Observations of Rainfall from Warm Clouds," by W. A. Mordy and L. E. Eber; "Turbulence in Clouds as a Factor in Precipitation," by T. W. R. East and J. S. Marshall; and "The Terminal Velocity of Snow Flakes," by M. P. Langleben. Wed., May 19, 5 p.m.

Royal Society of Arts

LONDON
"The Society's House and Earlier Homes," by John N. Summerson. Peter Le Neve Foster Lecture. Wed., May 12, 2.30 p.m.
"Engineering Developments in Central Africa," by Sir William Halcrow. Tues., May 18, 5.15 p.m.

Royal Statistical Society

LONDON
Symposium on "Interval Estimation." "Some Problems in Interval Estimation," by E. C. Fieller; "Limits for the Ratio of Means," by Miss M. A. Creasy; and "Confidence Intervals for Parameters in Markov Auto-regressive Schemes," by S. T. David. Research Section. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., May 12, 5.15 p.m.
"Post-Budget Outlook for 1954." Papers by J. R. N. Stone, Professor F. W. Paish and John Ryan. Study Section. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Wed., May 12, 6 p.m.
"Non-Response and Clustering in Sample Surveys: An Experimental Study," by J. Durbin and A. Stuart. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., May 19, 5.15 p.m.

Society of Instrument Technology

LONDON
Annual General Meeting. Manson House, 26 Portland-place, W.1. Tues., May 25, 6 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Institute of Fuel, 18 Devonshire-street, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Newcomen Society, 43 King's-road, London, S.W.3. (SLOane 8883.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Society of Instrument Technology, 55 Tudor-gardens, London, W.3.